INTRODUCTORY

CLASS-BOOK OF BOTANY

FOR USE IN

NEW ZEALAND SCHOOLS.

BY

GEORGE M. THOMSON, F.L.S.,

SCIENCE MASTER IN THE DUNEDIN HIGH SCHOOLS.

PART I.—STRUCTURAL.

PART II.—SYSTEMATIC.

WELLINGTON:

GEORGE DIDSBURY, GOVERNMENT PRINTING OFFICE.

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Johannes C. Andersen

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PREFACE.

The plan adopted in this work is one which I have found very effective in teaching, and is intended to cover a two years' school course. The subject dealt with in the First Part is the Morphology (prominent structural features) of Flowering Plants; and the principle sought to be inculcated is that, if possible, all the knowledge acquired by the pupils should be gained by actual observation. The work is drawn up on the lines of Professor Oliver's "Lessons in Elementary Botany," a book which first furnished the author with a method of teaching. The value of botany in the school curriculum is that it trains the observational faculty in a way that no other subject does, and it is also an excellent means of teaching the art of clear, accurate, and graphic description. The Second Part of the work deals with the principles of classification, with especial reference to the indigenous and introduced plants of New Zealand. Strictly speaking, of course, classification should be based on a very thorough knowledge of the morphology, anatomy, and (particularly the) development of plants; but in practice it will be found convenient to acquire its main features at a comparatively early stage. Systematic work is itself valuable as a good training in method, and, besides, it greatly increases the interest taken by the pupils in their work. A certain amount of technical terminology is necessary in acquiring a knowledge of any science; but I have not introduced any terms except such as are in common use among botanists, and have avoided as far as possible any multiplication of such terms.

While the study of Morphology and Classification may be conducted in comparatively large classes with inexpensive apparatus, that of Histology and Physiology, and of the structure of cryptogamic plants, requires conditions which are difficult of attainment in schools—namely, small classes and somewhat expensive apparatus. I therefore here only give the first two years' work of a school course which ought to cover a period of at least three years, the third year being devoted to an introduction to microscopic botany.

If scientific work is to take the place in our schools which modern views seem to demand, then it must in the first place be thorough and practical, and a sufficiency of time must be devoted to it. Two hours a week for a period of three or four years is not too much to demand for this branch of science; but no provision has hitherto been made in the way of providing text-books for such a thorough study of the subject. This must be my excuse for adding one more to the many works which profess to teach the science of Botany.

G. M. T.

INTRODUCTION.*

The science of botany should be learned as far as possible observationally. The use of a text-book is only to guide the learner, who should not depend implicitly on any statement which is readily capable of verification.

In class-work every pupil should be furnished with a specimen of the plant or plants required. The difficulty of providing specimens for a class is inconsiderable if the pupils themselves undertake the work. When it has been ascertained what plants are available—and this depends, of course, very much on the season of the year as well as on the locality—then two or three of the class may be told off to provide all the specimens required for the next lesson. There is laid down a certain definite order of types to be examined, chiefly because by doing so the subject of classification is afterwards more easily taken up. In practice it is not easy to follow the specified order closely, on account of the greater or less difficulty of obtaining the required specimens at certain times of the year; but it will be found advisable to keep as near it as possible.

A most important feature in teaching botany is a constant use of class-exercises. The schedule system so extensively adopted at one time has been discarded as too limited in scope. It is found that when once pupils get into the way of using forms of the kind it is a difficult matter to get them to leave it. But suitable exercises are very easily obtained. As soon as a plant has been carefully gone over in detail and described by the class, some nearly-allied plant may be given to them, and they may be asked to examine and describe it themselves, noting all the structural features in which it agrees with and differs from that first described. Suppose, for example, that the creeping buttercup (*Ranunculus repens*) be the plant gone over in class, then one of the other common species (*e.g.*, *R. plebeius*, *R. lappaceus*, or *R. rivularis*) should

* Especially intended for teachers.

be taken, and the pupils themselves be made to describe it. Then a plant differing more widely, such as single garden anemone, or adonis-flower, may be taken, and the same method adopted. In each case the work should be gone over again by the teacher, so that errors may be corrected, and points which have been omitted may be noted. At first the text-book or the notes taken in class should be used as a guide, but later on the pupils should be made to depend on their memory alone for the correct terminology. Wherever possible they should be called upon to illustrate their exercises by drawings taken from the specimens before them. Some of the earlier attempts will be sufficiently discouraging, but by persistence the difficulty will be largely overcome.

A very large number of type-examples have been selected—far more than is usually considered necessary; but it is absurd to expect that school-pupils can acquire a good knowledge of structural botany from the examination, say, of half a dozen types. Repetition is necessary to impress any matter on juvenile minds, and it is only by actual examination of the numerous details of structure exhibited by the plants selected that pupils will be enabled to grasp satisfactorily the principles of classification. It will be noticed that most of the types selected are introduced plants, not indigenous to New Zealand. The reason of this is simply that in all the larger centres of population the native flora has to a great extent disappeared, and only introduced species are readily obtainable. But reference has been made, wherever it was considered advisable, to all those forms of native plants which are still somewhat readily accessible.

The only apparatus required for the work laid down here consists of a sharp penknife, a couple of needles set in wooden handles, and a pocket magnifying-glass; but every one should be provided with these requisites. In examining any plant it should be impressed on the pupils never to cut or tear their specimen to pieces until they have learned all that they can from it in its entirety.

PART I.

STRUCTURAL AND DESCRIPTIVE BOTANY.

ERRATA.

Pages 4 and 5. The 3rd line from bottom of page 4—" the under-side. Generally each leaflet has three main veins"—should be the 9th line of page 5.

Page 7. Last line, for " whorles," read " whorls."

Page 10. Line 26, after " 7-partite," read " much cut below."

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PART I.

STRUCTURAL AND DESCRIPTIVE BOTANY.

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CHAPTER I.

1. The Buttercup (*Ranunculus repens*).

The plants known by the name of Buttercups belong to several different species of one common genus, *Ranunculus;* but the one specified is the familiar creeping buttercup which is so abundant in grassy ground throughout New Zealand. This plant is not a native, but has been introduced here from Britain, and is now widely spread. In examining it we shall note all its conspicuous characters, employing in its description such technical terms as are in common use among botanists. These terms may seem difficult to master at first, but you will soon become quite familiar with them.

On pulling up the plant from the ground it is found to have a central tufted **rootstock**, from which numerous white branching root-fibres descend into the soil, while leaves and branches ascend. Notice that while all the parts below the surface of the ground are white, those above, with the exception of the flowers, are green. A plant like this, which is destitute of woody tissue in its stem, is called a **herb**, and as its branches trail along the ground it is said to be a **trailing** or **creeping herb.**

In young plants all the leaves spring from the rootstock, and there is no distinct stem, the plant being therefore said to be stemless (or **acaulescent***), and the leaves are termed **radical**† leaves, because they apparently spring from the root. In older plants several branches spring from the root-

* Gr. *a*, without; *kaulos* (Lat. *caulis*), a stem.
† Lat. *radix*, a root.

stock in addition to the tuft of radical leaves, and each of these—at distances of a few inches—produces leaves. On account of the leaves being thus produced singly along the stem and alternately with one another their leaf-arrangement is called **alternate.** The part of a stem or branch at which a leaf is produced is called a **node**, and the portion of stem between any two nodes is an **internode.** You will observe that some of these branches stand upright and produce flowers, while others trail along the surface of the ground. Notice also that at each node on these trailing branches there is a more or less evident thickening, and, while a tuft of leaves is given off on the upper side, there is occasionally also a tuft of root-fibres sent downwards, thus attaching the branch to the ground. The tuft of leaves is itself a secondary branch, closely resembling the central one in structure, and it arises in the angle made by the creeping stem and the leaf at whose node it is produced. This angle is called the **leaf-axil,** and the secondary branch is therefore said to be **axillary.** This, then, is one of the modes in which our plant propagates itself—namely, by sending out creeping stems which root at the nodes and thus form new plants.

The upright branches also produce leaves at intervals (called from their position **cauline** leaves), and secondary branches in their axils. Observe further that nearly all parts of the plant except the roots and the inner portions of the flowers are covered with white hairs, which are shortest and most numerous on the leaf-blades. These hairs presumably serve to protect the soft eatable parts of the plant against the attacks of certain leaf-eating insects.

Let us now examine the leaves, taking a radical leaf first. Notice that it has a very long stalk or **petiole**, and terminates in an expanded green portion—the **blade** or **lamina.** The very lowest portion of the petiole is widened out on each side into a wing-like base with which it sheathes the rootstock. The blade itself is divided into three separate **leaflets,** and is hence called **trifoliolate.*** (Pl. I., fig. 1.) (The general term **compound** is applied to all leaves which have more than a single blade on each petiole.) Each of the leaflets is further divided, usually into three lobes or segments, and these segments have their margins more or less deeply toothed or **dentate.**† The cauline leaves become more and more reduced in size the higher up the stem they are produced. Those lowest down
the under-side. Generally each leaflet has three main veins,
have the same general form as the radical leaves, but with shorter petioles, while those highest up of all have no petioles,

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* Lat. *tris*, three ; *foliolum*, a little leaf.
† Lat. *dens*, *-tis*, a tooth.

PLATE. I.

1. Trifoliolate leaf of Common Buttercup (Ranunculus repens).
2. Trifoliolate leaf of Clematis hexasepala.
3. Ovate crenate leaf of Pansy (Viola sp.), with pinnatifid stipules.
4. Palmatisect leaf of Geranium dissectum.

and are therefore said to be **sessile**,* while their leaflets and segments become narrower and less toothed, and in some cases are reduced to a single leaflet.

If we now examine the blade somewhat more closely we see that it is composed of a number of spreading veins from which numerous finer veinlets branch off, the whole forming a framework or skeleton of fine fibres on which the green tissue of the blade is spread out and supported. This is best seen on coresponding to the lobes, from which branches go off to each of the smaller segments. The arrangement of veins in a leaf-blade is termed its **venation**,† and the particular kind occurring in the buttercup is **netted** or **reticulated**.‡

At the extremity of the more erect stems we find the flowers placed, one or more being produced from the axils of the upper leaves. Each flower is on a furrowed stalk or **peduncle**, which is often several inches in length. Now take a flower and remove the individual parts, laying them out in rows in front of you. You will find there are four sets of organs, arranged nearly in a circular manner, constituting the flower, each of which—as you will probably find out by other examples later on—is a modified leaf of some kind or other. The outer set of leaves, which are also lowest down, are yellowish-green in colour. These are the **sepals**, and we speak of the whole set or **whorl** of five as the **calyx**. The next whorl, attached a little higher up, is composed of five shining-yellow leaves—the **petals**—together spoken of as forming the **corolla**. It is these that in popular significance constitute the flower. The third set of organs consists of a large number of slender stalks bearing yellow heads; these are the **stamens**. (If we wish to be very technical, we call the whole assemblage of these the **andrœcium**.) Having removed and arranged before us all these three sets of floral leaves, we find that there still remain numerous small green organs, like miniature short pea-pods, crowded on the very top of the flower-stem; these are the **carpels**, the whole group of them constituting the **pistil**.

We may further notice at this stage that the top of the peduncle on which all these four sets of floral leaves are arranged is somewhat different from the portions below. This slightly-elongated portion is called the floral **receptacle** or **thalamus**. Before proceeding to examine in detail the different parts we have named, take another flower and cut it longitudinally into two halves. This is best done by splitting it with a sharp knife from the flower-stalk upwards through

* Lat. *sedeo*, *sessum*, to sit.
† Lat. *vena*, a vein.
‡ Lat. *reticulum*, a little net.

the receptacle. In this section we can see the order in which each of the whorls is fastened.

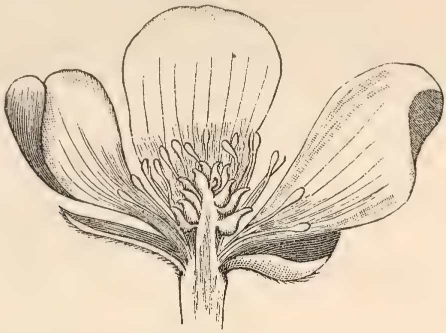

Fig. 1. Longitudinal section through flower of Buttercup (slightly magnified).

The **sepals** are not very unlike simple foliage-leaves: they are oblong, somewhat concave or boat-shaped, and very hairy on the outside. In the buds they are seen to cover over the other parts, and we therefore consider their function to be chiefly that of protecting the more delicate parts within. Notice also that in the buds the sepals lie in a particular order: the edges of one of them overlap the one on each side of it; these, again, overlap the inner two, one of which overlaps the other by one margin; so that one is really the outermost of the five, and another the innermost. The arrangement of sepals and petals in the bud is called their **æstivation**,* and this is said to be **imbricate** when their edges overlap one another as in this case. All five sepals are separate from one another, and therefore we say their **cohesion** is **aposepalous**† (or **polysepalous**),‡ the term "cohesion" being applied to the union or relation of parts of the same whorl to each other. They are also attached to the receptacle below the other whorls, and so we say their **adhesion** is **inferior**, the term "adhesion" being applied to the union of the organs of different whorls to each other.

The five **petals** are of a bright golden-yellow colour, and are attached by a very small base to the receptacle underneath the stamens and pistil. Being all free, their cohesion is **apopetalous** (or **polypetalous**), while their adhesion is said to be **hypogynous**,§ which really means the

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* Lat. *æstivus*, pertaining to summer, because flowers usually open in summer. The term *præfloration* is preferable to *æstivation*, but the latter term is generally adopted.

† Gr. *apo*, from; } both terms referring to the freedom of the se-
‡ Gr. *polus*, many; } pals or petals from each other.

§ Gr. *hupo* (*hypo*), under—the *gynœcium*, or pistil.

same as "inferior," only for distinction's sake the latter term is confined to the adhesion of the sepals and pistil. Note that each petal is **obovate** in shape—that is, like an egg with the broad end upwards—and on its inner face near its base is a little scale, within which is a small quantity of honey, or nectar. This little organ is therefore termed a **nectary** (*n*, fig. 2), and its function is to attract certain insects to the flower. The bright colour of the petals serves the same purpose; and, as we shall see later on, insects have a very important work to perform in regard to the flowers.

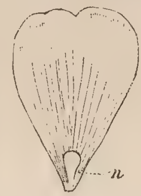

Fig. 2. Petal of Buttercup; *n* = nectary (mag. × 2).

Each **stamen** consists of a slender stalk or **filament** (*f*, fig. 3), bearing an elongated yellow head, the **anther** (*an*). This anther consists of two halves or lobes, which are attached to the top of the filament by their whole length, and are hence said to be **adnate.*** If the flower under examination has been open for a day or two some of the anthers will be found to have opened (or **dehisced**†) by **lateral slits** which extend longitudinally along their whole face, and from these slits very small yellow powdery grains—the **pollen-granules**—are seen to be escaping. Their structure, however, cannot be made out without the use of a microscope. (If you can examine them mounted in a solution of sugar under a high power, you will find each grain to be a small smooth spherical cell with granular contents.) This pollen is the most important part of the stamens, as without it no seed could be produced in the carpels. It may be termed the male element of the plant, and the stamens therefore the male organs. The stamens are all separate from one another, and we call their *cohesion* **polyandrous,**‡ while from being fastened on the receptacle under the pistil their adhesion is said to be hypogynous, as in the case of the petals. (Whenever stamens or carpels are very numerous it is not necessary to count them carefully; they are said to be **indefinite,** a term which is shortly expressed by the mark ∞.) If they are counted, however, it will often be found that their number is a multiple of that of the sepals or petals, and that they are in several distinct whorls.

Fig. 3. Stamen of Buttercup, dehiscing by lateral slits (mag.).

* Lat. *ad*, to; *natus*, born.

† Lat. *dehisco*, I split open.

‡ Gr. *andros*, of a man—in allusion to the male function of the stamens.

The fourth whorl of floral leaves, left after the sepals, petals, and stamens have been removed, consists of numerous small green carpels. Remove one of these with the point of

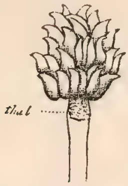

Fig. 4. Pistil of Buttercup; showing the thalamus or receptacle underneath (mag.).

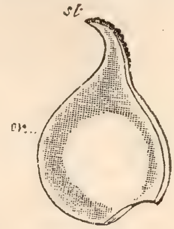

Fig. 5. Carpel of Buttercup (mag.); *st*=stigma.

a knife-blade or needle, and examine it under the lens. It is found to be a short pod-like body, with the lower portion considerably swollen and bulged, and the upper portion slightly hooked. Notice that the apex of this upper portion appears to be formed of small damp projecting cells, or papillæ. This portion is called the **stigma,** and its papillose viscid (sticky) surface enables it to catch and retain any pollen-grains which come in contact with it. Now make a longitudinal section through the carpel. If you have a very sharp knife—as you ought to have—this can be done, with a little practice, by holding the carpel between the finger and thumb; or you may take a little bit of the pith of an elder and, making a slit in it, place the carpel into it and cut the sections in the way desired. You will find that the carpel is hollow, and has attached to the lower end of the swollen portion, or **ovary,** a rudimentary seed or **ovule.** The narrower portion of the carpel above the ovary, and which bears the stigma, is called the **style**; it is not, however, well-defined in the buttercup, and you will meet with much better examples in some of the other plants to be examined later on. Notice now that all the carpels are quite separate from one another; we therefore say their cohesion is **apocarpous,*** and from being fastened above the other parts of the flower their adhesion is said to be **superior.**

It would not be an easy matter to prove directly that the stamens and carpels of a buttercup are modified leaves of some kind, and yet if you examine the common Bachelor's Button of the garden you will find just a buttercup in which all the stamens and most of or all the carpels have turned into petals. However, we shall probably come on examples of other flowers which will help us to prove this fact more satisfactorily.

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* Gr. *apo*, from; *karpos*, a fruit.

You must now try to find an example in which the fruit is nearly ripe. In this you will see that the sepals, petals, and stamens have fallen off, leaving minute scar-like markings on the thalamus, and that this portion has somewhat elongated. Only the carpels remain, but these have increased considerably in size, are now dry, smooth, and polished, somewhat compressed, and with a flange or margin, and the style has become sharper and more hooked. This sort of fruit does not open to scatter its seed, but in course of time the wall or **pericarp** * decays, and the seed is thus liberated. Such a fruit is called an **achene**,† and we define an achene as a 1-celled (*i.e.*, having one cavity), dry, indehiscent (not opening) fruit, formed of a single carpel and containing a single ovule.

Remove one of these little achenes and open it. You will find that the ovule has ripened into a seed, and that this seed is attached at one side of the base of the fruit. Now make a longitudinal section so as to cut the seed lengthways. The greater portion of it is occupied with a white substance (like the white of a coco-nut), which is the **albumen** or **endosperm**.‡ Near the base of this occurs a very minute firmer body called the **embryo**, which is the rudiment or germ of the future plant. Enclosing the albumen is a thin brown shell, or **testa**. Under favourable conditions of warmth and moisture the seed germinates, and the embryo gradually develops a root and a leaf-bearing stem. To do this it uses up the store of albumen which has been laid up for it — a process analogous to that by which the little germ in the hen's egg uses up the nutriment stored up for it, and so develops into a chicken. A seed like this of Buttercup, having a small slightly-developed embryo and a relatively large separate store of albumen, is said to be **albuminous**.

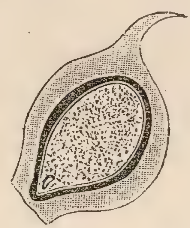

Fig. 6. Longitudinal section through achene of Buttercup (mag.).

Looking over the structure of our flower again, we see that the *sepals* are leaves specially modified to protect the parts within them, the *petals* serve chiefly as organs of attraction to insects, the *stamens* contain the pollen, or male element, and the *pistil* contains the ovules, or female element. Hence the two latter are the important or *essential* organs, and are called the *organs of reproduction*. The two outer whorls are therefore sometimes called non-essential organs, though the term is not quite correct, as, even if they do not actually take

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* Gr. *peri*, round about ; *karpos*, a fruit.
† Gr. *achanēs*, not opening.
‡ Gr. *endon*, within ; *sperma*, a seed.

part in the formation of the fruit, they materially aid in bringing it about.

Having now learned something of the general structure of the common creeping buttercup, it will be advisable to take examples of all the other kinds of buttercups you can find in your neighbourhood, and compare them with that just gone over.* Of course, it will depend very much upon your particular locality in New Zealand as to what species you will come across, but the following are among the commoner species :—

Ranunculus plebeius. Similar in most respects to *R. repens*, but with erect stem, and more hairy. Common in open grassy ground which has not been cultivated.

R. lappaceus. Also common along with the preceding. The leaves are simple (not compound), undivided or 3-lobed ; flowers sometimes with only 3 or 4 petals.

R. rivularis grows, as its name implies, in wet ground. It is perfectly glabrous (*i.e.*, destitute of hairs) ; leaves variable in shape ; peduncles long and slender, usually ending in a single flower ; petals varying from 5 to 10, and occasionally white-coloured.

R. acaulis. A little, creeping, glabrous species, common in damp sandy or gravelly ground, particularly near the sea-side. Leaves small, 3-foliolate, usually with undivided leaflets.

R. bulbosus. An introduced species, very common in many parts. The stem is erect, and much swollen at the very base ; the leaves are much divided.

R. acris. (Introduced.) A common, tall, hairy species. Leaves 3 to 7-partite. Flowers 1in. diameter.

R. parviflorus. (Introduced.) Particularly common in the North Island. Leaves simple, 3-lobed or undivided. Peduncles usually springing from opposite the leaves, and not in the leaf-axils. Flowers small, sepals turned back ; the achenes with straight styles, and their surface covered with small rough hooked points.

R. sceleratus. (Introduced.) Particularly common in the interior of Otago, usually growing in damp ground. Quite glabrous, branches erect, leaf-segments narrow, thalamus elongated, with small polished achenes.

(This list is intended chiefly to enable teachers and others to recognise the different species, but only the most salient features are mentioned.)

In all these species of buttercup you will find that the general characters are very similar ; it is only in details—and sometimes in very small details—that they differ. And at this point you may note that to all plants botanists have given two names. The first of these is the *generic* name, or that of the *genus* to which the plant belongs, and is either derived from Latin or Greek, or is a Latin noun made up from some proper name. Thus, *Geranium* is from the Greek *gerănos*, a crane (from the form of the fruit) ; chickweed belongs to the genus *Stellaria*, derived from the Latin *stella*, a star (in allusion to the star-like flowers) ; while some New Zealand alpine plants have been named *Hectorella* and *Haastia*, in honour of Drs. Hector and von Haast respectively. The second name —the *specific*, or that of the species—is always a Latin adjective, or a

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* For class-work the pupils should have one of the other kinds given to them, and be asked to compare it with the description of *R. repens*, noting down all points of difference which they observe, and *carefully drawing* those parts which differ. In this way every available species of *Ranunculus* in the neighbourhood should be gone through, and thus the type, as well as its variations, will be impressed on the mind.

genitive of some proper name, and should always agree with the first name in gender. Thus, to take the genus *Ranunculus* again, we have the following specific names among others: *repens* (creeping), *plebeius* (common), *parviflorus* (small-flowered), *lyallii* (in honour of the late Dr. Lyall), and so on.

1a. White Clematis.

There are several species of *Clematis* found in New Zealand: the most familiar one is the large-flowered white one—*C. indivisa*—which occurs commonly on the edges of the bush. Note its habit, and try to trace its stem to the ground. It is a shrub with a very tough climbing stem, which straggles over and through other shrubs and trees often to a great height. This climbing habit is in some respects perhaps disadvantageous to the plant, as it renders it dependent on others for support; but this is more than counterbalanced by the small amount of tissue it requires to produce. Compare the thickness of its stem with that of the plant on which it grows, and you will find that the latter has had to develop far more dead tissue (for the most of the wood is merely dead supporting-tissue) than the former.

Observe the leaves. The petioles are somewhat long and curving, and come off in opposite pairs from each node; hence we say the leaf-arrangement of this plant is **opposite.** (Pl. I., fig. 2.) Each petiole bears three blades or leaflets, but these leaflets differ very considerably from those of any of the buttercups examined. They vary in shape, but as a general rule are broad at the base and narrower at the apex, so as somewhate to resemble an egg in outline, and are therefore called **ovate**;* their margins are either **entire** (*i.e.*, not cut into at all), or they are more or less marked with blunt notches or lobes. In consistence they are tough and leathery (= **coriaceous**†), and their surface is glabrous and glossy, while through the blade the reticulation of the veins is easily made out. Now, if you examine a number of the petioles, particularly near the end of a branch, you will see how this plant climbs. Some of them are probably to be found bent or coiled into a spiral, and you may find that in tearing them off the tree or shrub on which they are growing you have brought away some bits of the branches round which they are coiled. When young these petioles are very sensitive to friction, and if they be gently rubbed they will slowly turn in the direction from whence the friction comes. This has been experimentally proved by Darwin and others. In its native state, when the young petioles of a plant are disturbed by the wind and are thus rubbed against adjacent twigs or branches they slowly

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* Lat. *ovum*, an egg. † Lat. *corium*, leather.

turn round these, and thus coil themselves firmly on to this support. It would be quite easy for you to prove this fact of the irritability of the petioles for yourself if you had a young plant of *Clematis* in a pot in the house or in a greenhouse; but the experiment is not one which could be satisfactorily demonstrated to a class, so you must accept the statement regarding it on the authority of those who have conducted this and similar experiments.

Observe the handsome flowers and their arrangement. They do not stand singly on their stalks, but are produced in large branching clusters towards the ends of the stems. These clusters spring from the axils of the upper leaves. Notice that at a distance of about an inch from the main leaf-axil in which it stands it bears a pair of very short rudimentary leaves, from the axil of each of which springs a slender flower-stem. This generally bears another pair of rudimentary leaves, and ends in a single flower; and this process is repeated to the extremity of the cluster. The main stem of the cluster is here called the **peduncle**; the secondary stems, bearing the individual flowers, are **pedicels**; the rudimentary leaves on the flower-stems are **bracts**; while the whole cluster or inflorescence is said to be a **cymose panicle.** (The meaning of this term will be more readily comprehended later.) You will find that the bracts repeat the same arrangement as the ordinary leaves—viz., they are in opposite pairs, and the pairs are at right angles to each other, so that from their position and arrangement we believe they are derived from foliage-leaves. What, then, is the explanation of their rudimentary condition? It is probably this: that as the flowers depend largely for the conveyance of their pollen to the stigmas upon insects, it is essential that they should be as conspicuous as possible; and this is attained in this way, among others—by the leaves in whose axils they stand being reduced to the very smallest size, so that it is only by their position that we know they represent leaves at all. (In some species of *Clematis* you will find the clusters are almost reduced to solitary flowers.)

The flowers when fully open vary from 1½in. to nearly 4in. in diameter. Note the outer whorl of 6 (sometimes 7 or 8) white sepals, which are free (aposepalous) and attached below all the other whorls (inferior). On the outside they are covered with a fine down, or **pubescence** (hence they are said to be **pubescent**), which also covers the pedicels and bracts; on the inside they are of a pure shining-white, or in the smaller forms of a greenish-white. In the buds these sepals are placed edge to edge, and this form of æstivation is called **valvate.** Note the total absence of petals, the sepals acting both as covering and attractive organs. (From their resem-

blance to petals they are called **petaloid.**) Now take particular note of the stamens and carpels, for the *Clematis* has usually two kinds of flowers. In the larger and more showy kind you will find a very large number of stamens with pink

Fig. 7. ♂ flower of *Clematis indivisa*, the pedicel bearing two bracts.

filaments and yellow anthers, *but no carpels.* In the smaller greener forms you will probably find a single ring of stamens, while the interior of the flower is occupied with a tuft of silky carpels. You have probably only gathered one of these kinds, so you should look for the other in order to compare them. In the larger form, then, a very large number (∞) of stamens only are produced; these stamens in general structure are like those of the buttercup, being all separate from one another (polyandrous), and they have two-celled adnate anthers opening by lateral slits and discharging a very large amount of pollen. As these flowers have stamens only and no carpels

(they are termed **staminate** flowers—represented by the mark ♂, or male—and therefore) they cannot produce any seed. Now examine some of the smaller specimens. Note the single ring of stamens, and make a transverse section through the anthers: you will then find *there is no pollen in them.* Now remove one of the carpels from the central tuft, noting the small lower portion or ovary covered with silky hairs, and the long silky style with its small terminal stigma. On making a longitudinal section through the ovary you will observe the single ovule, as in buttercup. This kind of flower has both stamens and carpels present, but the former are in an imperfect condition, and are useless. Their presence can only be explained on the theory that they are relics of a former condition of things, the ancestors of this species having probably had flowers in which both perfect stamens and carpels were present.

Flowers which have both stamens and pistils present are said to be **hermaphrodite** (represented by ☿), those with stamens only are **staminate** or male (♂), those with pistil only are **pistillate** or female (♀). In some species of plants you will find that the same specimen produces both staminate and pistillate flowers, and these plants are called **monœcious**: a familiar example is the vegetable marrow. In other species one plant produces staminate flowers only, and a separate plant produces pistillate flowers only, and these are called **diœcious**: you will meet with many examples later on. Lastly, some plants bear hermaphrodite, staminate, and pistillate flowers apparently indiscriminately, and these are said to be **polygamous**: these also are common enough.

Now, our *Clematis* has staminate flowers on one plant and pistillate flowers on another; for, though these latter have a ring of stamens present, they are quite useless (so that, though these flowers are *structurally* hermaphrodite, they are only pistillate *in function*). Therefore we say this *Clematis* is a diœcious species.

Fig. 8. Achene of *Clematis afoliata*, showing persistent plumose style (mag. ×2).

The examination of the fruit will have to be done later on in the season; for, while the flowers usually come out from August to October (according to the locality), the seeds only mature from about January to March, whereas in buttercup and many other kinds of flowering plants you can often get flowers and fruit on the same plant. On obtaining the fruit notice that the style has remained attached to it (= **persistent**), and now forms a long feathery plume, the object of which manifestly is to carry away the seed to some distance

by the agency of the wind. Make a longitudinal section of the ovary, and note the single seed **pendulous** from the apex of the cavity. You may also be able to distinguish the delicate little stalk (or **funiculus**) by which it is attached. You will see that the seed has the same general structure as that of the buttercup—viz., a small embryo with a large store of endosperm, only in *Clematis* the embryo is at the apex and not at the base of the achene.

There are several other species of *Clematis* in this country besides *C. indivisa*, which differ from it in various small details. It will be advantageous to compare these where possible.

It will now be advisable to compare specimens of any or all of the following plants with those already described, noting particularly the points of agreement and difference.

Anemone.—Any single garden variety will do. Three leaves or bracts under the flower acting as a calyx, petaloid sepals, no petals except where the flowers have become double, when the outer stamens are more or less petaloid.

Adonis sp., commonly cultivated in gardens as *Flos adonis*.—Very near buttercup in structure.

Love-in-a-mist or Devil-in-a-bush (*Nigella* sp.).—The popular names derived from the numerous much-divided bracts encircling the flowers. Carpels 5, joined together, with numerous ovules on the lines of union. Fruit a capsule dehiscing septicidally (see p. 56).

Columbine (*Aquilegia vulgaris*, &c.).—5 petaloid sepals, 5 petals produced backwards into spur-like nectaries, outer stamens reduced to scales, 5 joined carpels. Fruit consisting of 5 follicles (see p. 54).

Larkspur (*Delphinium* of various species).—5 unequal petaloid sepals, the posterior produced into a long spur; (2 or) 4 small petals, the upper produced into a spur, which is contained in the spur of the calyx; 1 or more (up to 5) carpels, ripening to follicles.

Still more diverse from any of these than these are from each other is the Pepper-tree (*Drimys axillaris*). Note the habit—that of a small erect tree, with simple, alternate, spotted leaves. The flowers are either in the axils of the leaves or on the scars of the old leaves; the sepals are united into a cup-like calyx, which shows 2 or 3 imperfect lobes; the petals are usually 6, arranged in two rows; the stamens are about 15 to 20 in number, with short thick club-like filaments and adnate anthers. In the centre of the flower are 2 or 3 short thick carpels, with small sessile stigmas; in transverse section they are 1-celled, with 2 or 3 ovules arranged along one side (the ventral suture). These ripen into berries.

Compare *Magnolia grandiflora* with these.

CHAPTER II.

2. The Wallflower (*Cheiranthus cheiri*).

The plants which you have hitherto examined have been on the whole apparently rather diverse from one another, and yet they show a remarkable similarity in certain points. Thus, in their flowers there are usually 5 free inferior sepals, 5 free hypogynous petals, ∞ free hypogynous stamens with adnate anthers, and seeds with small embryos in a large quantity of albumen. There are also other points in which they resemble each other more or less. Those now to be examined are different in many of their characters from those of the previous group, but show a still closer agreement with one another. We may take the Wallflower as a type, as it is to be found in nearly every garden.

The plant is an erect herb, so woody in the stem as almost to be termed shrubby; its leaves are simple, about lanceolate-oblong in shape, and usually entire in their margins. The arrangement of the flowers is very distinct: each flower is on a short pedicel, and these pedicels are arranged alternately along a common peduncle or **rachis.*** The lowest flowers are the first to open, and the rachis goes on lengthening and producing flowers as long as the plant continues to grow freely. Any inflorescence in which the lowest or outermost flowers of a cluster open first is said to be **indefinite,** and this particular form in which the flowers are on pedicels arranged along a rachis is called a **raceme.** Notice that each flower has 4 inferior sepals, 4 hypogynous petals, 6 hypogynous stamens, and an elongated superior ovary in the centre. The sepals are slightly pouched (**saccate**†) at their base, and are very **deciduous**‡—*i.e.*, they fall off readily after the flowers have been open for a day or two. Each petal has a long narrow lower portion, or **claw,** and a spread-out blade, or **limb,** and the whole four petals stand crosswise. The stamens are in two rows, two of them being placed lower down in the outer row, and four standing higher in the inner row, and at right angles to the others. The anthers therefore appear to be at different levels; and this arrangement of 6 free stamens—viz., 4 long and 2 short—is

* Gr. *rhachis*, the back-bone. † Lat. *saccus*, a sac or pouch.
‡ Lat. *de*, down; *cado*, I fall.

called **tetradynamous.*** Notice that the anthers, instead of being adnate, as in buttercup, are only attached to the filaments by a small point at the back near their base. The ovary bears a sessile stigma on its summit (there being no style), and, as this is indistinctly 2-lobed, we are led to believe that the ovary is made up of two united carpels: this cohesion is termed **syncarpous.**† This impression is confirmed by making a transverse section through the ovary, when we find that it is 2-celled, being divided into two cavities by a thin partition. The numerous ovules are arranged along the walls on each side of the partition in two series. This is better seen by splitting off one of the valves which form the sides of the ovary, when you will notice that the ovules are arranged alternately along both walls. Now, the portion of an ovary bearing the ovules is called the **placenta**, and the arrangement of the ovules is therefore their **placentation**: this kind in which they are arranged along the walls is said to be **parietal.**‡ The division-walls of an ovary are called **septa**§ or **dissepiments**;|| but, as will be explained later on (p. 55), the septum in the ovary of wallflower and similar plants is considered to be a *false dissepiment*, and is termed a **replum.**

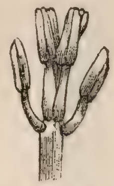

Fig. 9. Tetradynamous stamens of Wallflower.

Fig. 10. Transverse section of ovary of Wallflower (mag.).

Each ovule has a short stalk (funiculus) directed downwards. Remove one or more of the ovules and examine them carefully; the riper they are the more easily will their parts be made out. Each is of an oblong much-compressed form, and with the testa produced—chiefly at the lower margin—into a thin white border or flange. On removing this testa you will find the interior to consist of a well-developed embryo without any albumen. You can usually get the embryo out easily by removing the testa a little at one end, and gently pressing from the other end with a needle. Notice that it consists of two nearly flat oblong green seed-leaves, or **cotyledons**, with a long green **radicle**, or rudimentary root. The radicle while in the ovule lies along the edges of the cotyledons, and hence the latter are said to be **accumbent.**

Fig. 11. Transverse section of seed of Wallflower (mag.).

* Gr. *tetra*, four; *dunamis*, power.
† Gr. *sun*, together; *karpos*, the fruit.
‡ Lat. *paries*, *parietis*, a wall.
§ Lat. *septum*, a division.
|| Lat. *dissepio*, I divide.

(These small ex-albuminous ovules should be again examined after the structure of the seed of the bean has been studied.)

Fig. 12. Siliqua of Wallflower, with one valve removed.

The fruit, which consists of the matured and somewhat dried ovary, is greatly elongated, and dehisces by the splitting-away—from below upwards—of two longitudinal valves, the replum and the placentæ with their attached seeds being left. This kind of 2-celled, 2-carpelled fruit is called a **siliqua**,* and is very characteristic of the group of plants to which the wall-flower belongs.

Compare with the preceding any of the following cruciferous plants:—

Single Stock (*Matthiola* sp.).
Virginian Stock.
Water-cress (*Nasturtium officinale*).—Note the lobed leaves, the short racemes, and the stamens often fewer than six.
Cabbage (*Brassica oleracea*), or any of its varieties.
Turnip (*Brassica rapa*), or Rape, or Mustard.

Observe the seed with its two cotyledons folded along their whole length, and with the radicle lying along the back of the fold. If you have not fresh seed of cabbage or turnip, old seed—put into a cup with a little boiling water and soaked for half an hour—will do excellently.

2A. Shepherd's Purse (*Capsella bursa-pastoris*).

This is a very common weed in all cultivated ground, and, like many other of our weeds, has been introduced here from Britain.

Note its two kinds of leaves: the petiolate *radical* leaves are usually **pinnately lobed** or **pinnatifid** † (*i.e.*, their blades are deeply cut into laterally), the upper portion being only slightly lobed; the sessile *cauline* leaves are lanceolate in form, usually slightly **dentate** (*i.e.*, toothed) on the margins, and their bases are prolonged on both sides so as to clasp the stem (=**amplexicaul**‡). Note the very small flowers in elongated racemes, the parts being similar in number and arrangement to other cruciferous plants. The 2-celled ovary is **obcordate**§ (like an inverted heart), or **obcuneate**,|| being broadly wedge-shaped below, and with a notch or depression in the upper margin, in which the minute stigma is placed.

* Lat. *siliqua*, a pod or husk.
† Lat. *pinna*, a feather or fin; *findo*, *fidi*, &c., I cleave.
‡ Lat. *amplexor*, I embrace; *caulis*, the stem.
§ Lat. *ob*, reversed; *cor*, *cordis*, the heart.
|| Lat. *ob*, and *cuneus*, a wedge.

In transverse section the ovary is seen to be very much laterally compressed, the replum being across its narrowest diameter, and the ovules are very numerous on parietal placentæ. So quickly do the seeds ripen that you will probably find ripe fruit and the remains of the fruit on the lower part of the same raceme that bears the flowers. The dehiscence is the same as that of the wallflower—viz., by two valves, which in this case are somewhat boat-shaped; but, as the fruit is not longer than it is broad, it is called a **silicula**, not a siliqua. You will find the seeds are rather small for examination.

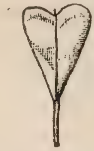

Fig. 13. Obcordate silicula of Shepherd's Purse.

Fig. 14. Transverse section of silicula of Shepherd's Purse.

Compare any of the following plants with the preceding:—

Sweet Alyssum (*Alyssum odoratum*).—Note the nearly circular siliculæ, containing only two or three seeds in each cell.

Cress, Candytuft, Honesty, &c.

Radish.—Note the indehiscent, often fleshy pods.

Cruciferous plants belonging to many genera, both indigenous and introduced, are common in the wild state and in gardens. All have a remarkable similarity of floral structure.

The seeds of the last-named plants are somewhat different from those of the cabbage. The Cress may be taken as an example. If only old seeds are obtainable, soak them in warm water, and notice that they exude a mucilaginous or gelatinous substance. Remove the brown testa, and notice that each cotyledon is 3-lobed, and that the radicle lies along the back of one of them. In this arrangement of the cotyledons they are said to be **incumbent** to the radicle.

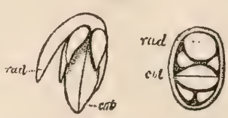

Fig. 15. Seed of Cress, in transverse section, and with the testa removed (mag.).

3. Pansy, or Heartsease (*Viola* sp.).

The Pansy is a highly-cultivated and much-hybridized violet. In habit it is a prostrate or trailing succulent herb, glabrous in all its parts, and with its stems always more or less 4-angled. The leaves are arranged alternately on the stem, but notice that at the base of each petiole a pair of leafy organs are developed, like wings. These are **stipules**, and all leaves possessing them are called **stipulate**. It is not a common thing to find the stipules so large in proportion to the leaf as they are in the Pansy. (You must take care in examining plants that you do not mistake small axillary branches

for stipules, as beginners are very apt to do. Remember that stipules are almost always produced *in pairs, one on each side of the base of the petiole.*) The leaves of Pansy are simple, ovate in form, with **obtuse*** (blunt or rounded) apex. The margin is notched into a few rounded teeth, and is therefore said to be **crenate.**† The stipules are like one-sided leaves with pinnatifid margins.

The flowers are arranged singly on long 4-angled pedicels, which spring from the axils of the upper leaves; hence the inflorescence is called **solitary** and **axillary.** You will see about three-fourths up the pedicel two small scale-like bracts; these are very characteristic of the violet tribe. The top of the pedicel is curved nearly at right angles, so as to bring the flower into such a position that insects may easily alight on it. The flower is said to be **irregular,** because its petals are variously shaped. Note the 5 aposepalous inferior sepals, attached not by their base, but somewhere below their middle, so that each appears to be produced backwards into a nearly square lobe. They overlap one another, hence their æstivation (or mode of folding in the bud) is called imbricate;‡ and, as they do not wither and fall away when the rest of the flower withers, but remain attached to the fruit, they are said to be **persistent.**

Note that the 5 petals are apopetalous and hypogynous, and that they also are *imbricate*, the lowest or front petal being the innermost, and one of those on the back the outermost. You will see that the lowest petal is produced backwards into a short spur, which projects between two of the sepals. This inferior petal and the one on each side of it usually have strongly-marked lines of colour converging towards the centre, and these probably serve to direct insects to the spur, which acts as the nectary of the flower. This flower—like the wallflower—is sweetly scented, and this fragrance constitutes a further attraction to insects, in addition to the bright colour of the petals, and the nectar which is probably present in the spur.

In order to make out the character of the staminal whorl, it is advisable not only to remove the sepals and petals from one flower, but also to make a longitudinal section through another, taking care to divide the spur of the lower petal into two. Note the 5 stamens, carefully removing each with a needle. They are all separate from one another (**pentandrous** = five free stamens), and hypogynous in adhesion. Their filaments are so short and broad that the anthers are almost

* Lat. *obtusus*, blunt.
† Lat. *crena*, a notch.
‡ Lat. *imbricatus*, from *imbrex*, a tile.

sessile. Seen from the outside each stamen looks like a scale, but on the inner side you will observe the two anther-lobes, lying, as it were, under a hood. This scale or hood is the **connective,** or portion of tissue which connects the anther-lobes: in this case it is very greatly developed. Note that the two lower stamens have their connectives produced into thin spurs, which lie in the spur of the lower petal: they probably serve to secrete a little nectar, though in most pansies and violets you will not be able to detect this.

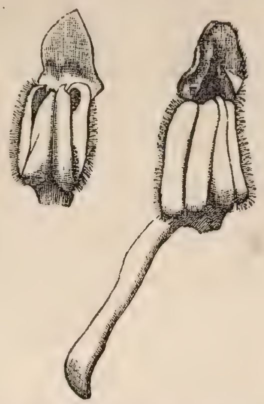

Fig. 16. Stamens of Pansy, inner face (mag.). The right-hand figure is one of the spurred form (mag.).

In the interior of the flower stands the oblong or slightly triangular ovary. Springing with a sharp curve from its apex is a short style, bearing a rounded head, in the front of which is the stigma in the form of a round hole. Make a transverse section of the ovary, when you will observe that it is 1-celled, with numerous ovules arranged on three parietal placentæ—*i.e.*, in three rows on the walls. From this we gather that the pistil is syncarpous, and formed of three united carpels.

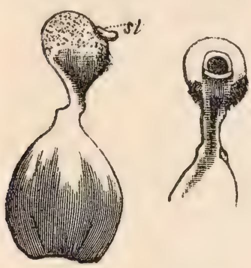

Fig. 17. Ovary of Pansy, from the side and in front (mag.). *st* = stigma.

Fig. 18. Transverse section of ovary of Pansy (mag.).

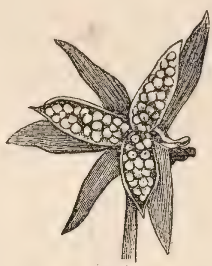

Fig. 19. Capsule of Violet after dehiscence.

Now see if you can get a fruit. You will find it consists of a dry brown capsule, dehiscing by three valves, the dehiscence taking place midway between the placentæ, so that each valve falls out carrying its row of seeds in the middle.

Examine any other species of Violet (*Viola*)—wild or cultivated—obtainable, and notice the great general similarity of structure which prevails, together with considerable difference of detail in all the parts. The leaves, stipules, flowers, &c., should all be drawn, as well as described. Next compare the common native shrubs or trees which go under the popular name of Hinahina (*Melicytus ramiflorus*, *M. lanceo-*

latus, &c.). Note the very minute stipules (best seen in leaves which are just freshly opened), the flowers crowded into small axillary bundles (fascicles), the two small bracts on the pedicels, the regular petals, the free stamens with the connective produced into a sort of club-shaped organ at the back, which bears a bead of nectar. These plants are usually quite diœcious, the ♂ flowers having no pistil, and the ♀ flowers having stamens whose anthers contain no pollen.

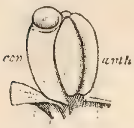

Fig. 20. Stamen of Melicytus (mag.).

Examine also in this connection the various species of Mapau (*Pittosporum*), so common in the bush. Note the absence of stipules on the leaves, the solitary or clustered flowers with 5 sepals, petals, and stamens, the ovary with 2 or more cells (up to 5), and the woody capsule dehiscing by valves. Note that the seeds are covered with a clear resinous secretion, and in longitudinal section show a small embryo in hard endosperm.

4. Chickweed (*Stellaria media*).

This commonest of weeds is a low-growing herb with feeble, succulent, trailing stems. Notice that the leaves are in opposite pairs, those lowest down having the longest petioles, while the upper ones are nearly sessile. The stems are **terete*** (circular or cylindrical in section), and between each pair of leaves runs a slender line of white hairs, while each node is distinctly swollen (**tumid**).† The leaves are simple, with *entire margins* and **acute** (sharply-pointed) apex. The inflorescence is of a well-marked type. If you follow up a stem towards the extremity, you find that it branches into two, and that in the fork a single flower stands on its pedicel. This flower terminates the main stem or axis, so that the growth of the stem has to be carried on by the two side stems or lateral axes. Every such inflorescence is said to be **definite**, and this well-marked form of it is called a **cyme.** But, as we shall meet with other forms of the cyme, this is further characterized as the **dichotomous**‡ (or 2-branched) cyme (see fig. 25, p. 24). You will find the following parts in the flower: 5 hairy, free, and inferior sepals, with white **scarious** (thin and papery) margins; 5 free hypogynous petals, each deeply cleft nearly to the base (**bifid**§); 3 or more (up to 10) free hypogynous stamens; and a small green globular ovary, with three white curved styles on the top. In the height of summer the flowers have usually well-developed petals, but later in the season these be-


Fig. 21. Bifid petal of Chickweed (mag.).

* Lat. *teres*, tapering as a tree.
† Lat. *tumidus*, swollen.
‡ Gr. *dicha*, in two parts; *tome*, a cutting.
§ Lat. *bifidus*, twice-cleft.

come smaller, and in winter are sometimes wanting altogether. This **apetalous*** condition is probably due to the fact that in winter there are few or no insects to fertilise the flowers, and therefore the conspicuous and attractive parts—viz., the petals and the little beads of nectar at the bases of the filaments—are frequently reduced, or disappear. Chickweeds are quite capable of self-fertilisation—that is to say, that if pollen from the anthers of a flower adheres to the stigmas of the same flower, the ovules in that flower will be fertilised, and will ripen into seeds. And in winter this is what very commonly happens. But it has been proved by experiments that even among flowers which are usually self-fertilised a cross-fertilisation is advantageous. If, namely, the stigmas receive pollen from some flower on a different plant, the seed produced by this cross-fertilisation is found to be larger and heavier, and to produce larger and stronger plants, than would have been the case had the stigmas received their own pollen. But it is clear that in the case of Chickweed only flying insects, such as small bees, flies, moths, or butterflies, could carry the pollen on some part of their bodies, and, as these insects are not to be found in winter, the plants seem to adjust themselves to their altered conditions, and go on producing flowers wanting the very parts so attractive to the insects.

Make transverse and longitudinal sections through the ovary, and notice that it is 1-celled, and contains numerous ovules on a central column, which does not reach much more than half-way to the summit. This column is in reality made up of a great number of separate stalks, or funiculi, which arise from the base of the ovary, and the form of placentation is called **basal.**

Fig. 22. Transverse section of ovary of Chickweed (mag.).

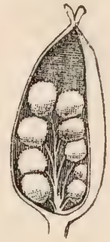

Fig. 23. Longitudinal section of ovary of Chickweed (mag.).

The ripe fruit is to be found at all seasons of the year, as only a very short time elapses between the withering of the flower and the ripening of the seeds. Notice that the pedicels of the flowers are nearly erect, but that as soon as the flowers have withered they begin to bend and at last hang down: this is evidently to let the seeds fall out as soon as they are ripe. The sepals remain attached as a covering to the ovary, the walls (pericarp) of which become thin and dry,

* Literally "without petals."

and ultimately split at the top by 6 teeth. The fruit is therefore a 1-celled capsule, dehiscing by teeth, and you will observe that the teeth are just twice as numerous as the styles.

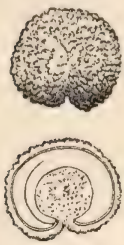

Fig. 24. Seed of Chickweed, entire and in vertical section (mag.).

Notice the small **reniform*** (=kidney-shaped) seeds, with their corrugated brown testa. Make a longitudinal section through one, and observe the curved embryo, surrounding a central mass of floury endosperm.

For comparison with the Chickweed, examine any of the following plants:—

Mouse-ear Chickweeds (*Cerastium glomeratum* and *C. triviale*).—These are common garden weeds, hairy all over, and having the cymose arrangement of their flowers very conspicuous. Notice the remarkable similarity in most points to the common Chickweed. The petals are not so deeply cleft, the stamens are always 10, styles 5, and the fruit an elongated capsule dehiscing by 10 teeth.

Fig. 25. Two-branched cyme of *Cerastium*.

* Lat. *rena*, a kidney.

Viscaria oculata, &c.—Common garden annuals. Note that the inflorescence is a 1-sided cyme, only one lateral branch being developed below each flower. The calyx is sharply 10-ridged, 5 of the ridges corresponding to the midribs of the united sepals, and 5 to their lines of union. (The sepals being joined, the cohesion of the calyx is said to be **gamosepalous.***) Note the 5 petals, each with a bifid scale at the junction of the claw and the limb, the 5 scales forming a **corona.** In the fruit, notice the dry inflated calyx with the ridges more strongly developed than they are in the flower; on removing it you will observe the withered remains of the petals and stamens adhering to the conical ovoid (=egg-shaped) ovary. Notice that the latter is mounted on a short stalk, which is a portion of the pedicel continued above the attachment of the calyx. Make a longitudinal and a series of transverse sections through the hard pericarp. You will find that 5 dissepiments spring from the walls and go almost into the centre, but are not in absolute contact with the column, so that the placentation is still basal. The dissepiments do not reach to the top of the ovary, so that the transverse sections taken near the top show a 1-celled ovary, while those about the middle appear to be 5-celled.

Fig. 26. Petal of *Viscaria.*

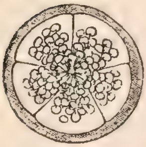

Fig. 27. Transverse section of ovary of *Viscaria* (mag.).

Fig. 28. Flowering branch of Spurrey.

Single Pink (*Dianthus* sp.).—Note the linear entire sessile leaves, arranged in opposite pairs, the 1-sided cymes (see Pl. II., fig. 11), the four bracts under each flower just like very short leaves, which indeed they

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* Gr. *gamos*, union.

are. In the flowers note that the petals are often fringed (**fimbriate**) on their outer margins, the elongated ovary with 2 styles and having the placenta continuous from the base to the apex producing what is called **free-central placentation**. (The Sweet William, *Dianthus barbatus*, has the same general characters, but the cymes are all crowded together at the ends of the branches.)

Spurrey (*Spergula arvensis*).—A common weed in many parts of New Zealand. It has rather an offensive smell when bruised, and is covered with sticky (glandular) hairs. You will notice that in several points it is different from the preceding forms. Its linear leaves appear to be **whorled**, several springing from each of the tumid nodes, and they have minute stipule-like scales at their base. The inflorescence in the lower part of the plant is a dichotomous cyme, but towards the extremities of the branches it becomes 1-sided. The ovary has 5 styles, but the capsule dehisces by 5 teeth only, not by double the number of the styles as in the preceding forms.

Besides the above there are numerous other allied plants which it is advisable to examine. These include many garden and wild plants, such as *Saponaria*, Campions (species of *Lychnis*), Catchfly (*Silene*), &c. All will be found to have numerous points of difference, but to agree in their general habit, entire opposite leaves springing from tumid nodes, their cymose inflorescence, parts of the flower (sepals, petals, and stamens) in fives, their capsular fruit dehiscing by teeth, having basal or free-central placentation, and their albuminous seeds with curved embryo.

5. Mallow (*Malva* sp.).

Various introduced species of Mallows are to be found wild in different parts of New Zealand, and these, while differing in details, such as their habit and form of leaves, agree very closely in general features. Hybrids of the Musk Mallow (*Malva moschata*) and the Tree Mallow (*Lavatera arborea*), which are to be found in many gardens, are also very similar.

You will find the following characters common to all these plants. The leaves are simple, alternate, and furnished with somewhat long petioles, at the base of which are a pair of small stipules. However different the general form of the leaves may be in the different species, they all agree in having five ribs springing from the top of the petiole, the lowest rib on each side often having a subsidiary one branching from it so as to make the leaf appear 7-ribbed. In *M. rotundifolia* the leaf is reniform with a somewhat crenate margin, but in most of the other species it is 5–7-**palmately-lobed**, or **palmatifid** (Pl. II., fig. 6), this term being applied to all such leaves in which the lobes are spread out from the summit of the petiole. If you examine the surface of a leaf or other part of the plant with a good lens, you will find that it is more or less covered with star-shaped (**stellate***) hairs. Note the arrangement of the flowers in axillary fascicles; under each flower is an outer whorl, or *epi-calyx*, of 3 bracts, which is usually persistent. The calyx is always gamosepalous, 5-lobed and inferior; and notice that in the buds the lobes are valvate. The 5 petals

* Lat. *stella*, a star.

PLATE II.

1. Simple, entire, elliptical-oblong leaf.
2. Simple, pinnatifid.
3. Compound, pinnate.
4. Compound, bipinnate.
5. Simple, entire, broadly cordate.
6. Simple, palmatifid.
7. Compound, digitate.
8. Rotundate leaf of Pelargonium australe.
9. Elliptical leaf of Pomaderris elliptica.
10. Oblong leaf of Caliixene parviflora.
11. Linear leaf of Panax lineare.
12. Ovate leaf of Viola cunninghamii.
13. Obovate leaf of Hymenanthera latifolia.

are twisted round one another (**contorted***) in æstivation, and are free and hypogynous, with their bases often slightly united. Note the very numerous stamens, with all their filaments joined into a tube, the base of which is usually joined to the petals. This form of cohesion is called **monadelphous**;† their adhesion is hypogynous. The anthers are free from one another, reniform in shape, and only 1-celled, the cells opening by a longitudinal

Fig. 29. Longitudinal section of flower of Mallow.

Fig. 30. Stamen of Mallow, with 1-celled anther (mag.).

semicircular line. On splitting the staminal tube carefully, you will observe the long style dividing at the top into as many stigmatic branches as there are carpels—viz., 7 to 10. The carpels are united to form a whorl round a central column or axis, consisting of a portion of the receptacle which is produced up between them, and is called a **torus**. Make a longitudinal section through a carpel, and note that it contains a single ovule attached to the lower and inner angle of the carpel.

Next examine the fruit (or, at any rate, some of the most matured carpels you can find). It is enclosed in the persistent epi-calyx and calyx, and the individual carpels as they mature and become dry separate from one another and from the central axis, but do not open to let the seeds fall out. These—as in the case of achenes—are only liberated when the pericarp decays. All such fruits which thus split up into their original carpels, but are not truly dehiscent, are termed **schizocarps**,‡ so we may call our mallow fruit a 7- or 8-partite schizocarp. Cut transverse and vertical sections through the carpels; notice the thick and rather spongy pericarp, the single seed with its more or less wrinkled testa con-

Fig. 31. Transverse section of carpel of Mallow (mag.).

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* Lat. *con*, together; *tortus*, twisted.
† Gr. *monos*, one; *adelphos*, a brother.
‡ Gr. *schizo*, I cleave; *karpos*, a fruit.

taining inside it the curved embryo, with large green folded cotyledons, within which again is a small quantity of mucilaginous (gummy) endosperm.

Compare with this type any of the following: *Malope*, *Hibiscus*, or *Abutilon*, which are not infrequently to be found in gardens.

Ribbon-wood (*Plagianthus betulinus*).—This plant grows to a tall tree, having small greenish-white diœcious flowers (without bracts), produced in much-branched fragrant panicles. The ♂ flowers have narrow petals and a number of monadelphous stamens; the ♀ flowers have a single carpel (containing a single ovule), which ripens into a capsule dehiscing down one side.

Houhere (*Hoheria* sp.).—Very abundant shrubs in many parts; easily recognised by their pretty white flowers, showing the malvaceous structure.

Fig. 32. Three-lobed petal of *Aristotelia* (mag.).

Fig. 33. Anther of *Aristotelia*; dehiscing by slits at the apex (mag.).

Compare with these the Makomako, or New Zealand Currant (*Aristotelia racemosa*), which differs in several respects. Note the exstipulate leaves, the small axillary panicles of pink or rosy-red diœcious flowers, usually with 4 sepals and 4 petals, each of the latter split into three lobes, and placed on a short torus or prolongation of the receptacle: the ♂ flowers with 12 free stamens arranged in 4 groups of 3 each, their 2-celled anthers dehiscing by apical slits or pores, and no pistil; the ♀ flowers often with a few more or less perfect stamens and a small 4-celled ovary. Each cell contains 2 small ovules, and the whole pistil ripens to a black berry.

Structure and Terminology of Leaves.

Only such forms of leaves as have been met with in the plants examined have hitherto been described. It will now be advisable to try to give you a clearer idea of the structure of leaves and of the different terms used in their description, so that these terms may be correctly applied in future. In the first place it is necessary to have some exact notion of what a leaf is, and what its use or function is. The term in its common acceptation is applied to the flattened green outgrowths of the stem which are chiefly concerned in the processes of respiration and assimilation of food-materials, but in the wider sense it is applied by the botanist to all leaf-like organs which are produced on the stem itself, exclusive of branches, which are stem-organs, and prickles, hairs, &c., which are outgrowths of the epidermis or outer skin. Thus the scales which form the bulb of a common onion are leaves, so are the scales which cover the leaf-buds of many plants in

spring (*e.g.*, poplars and willows), and which drop off as soon as these leaf-buds are ready to open; so also are bracts, sepals, and most probably petals, stamens, and carpels; and so, lastly, are the little cotyledons of the embryonal plant. All may be termed leaves, and are modifications of a common leaf-type, and yet when we apply the term *leaf* without further explanation we of course mean the foliage-leaf, the ordinary green leaf of the plant. Still, it is to be borne in mind that the terms which are used in describing the forms of these may equally well be applied to all other leaf-like organs. The functions of these other kinds of leaves are already known to you in some slight degree, but will be more fully referred to further on.

It is usual to say that all leaves are **simple** which have a single blade on each petiole, however much cut into this blade may be; while those are **compound** which have three or more blades. Of simple leaves, those which are cut into from their margin towards their midrib (Pl. II., fig. 2) are said to be **pinnately lobed** or **pinnatifid** if the divisions extend about half-way to the midrib, as in the oak; and **pinnati-sect** or **-partite** when cut very deeply down, as in some poppies. Those which are cut down towards the base (Pl. II., fig. 6) are said to be **palmately lobed** or **palmatifid**, as in maple; and **palmati-sect** or **-partite** if deeply cut, as in some buttercups and in *Geranium dissectum* (Pl. I., fig. 4). Compound leaves are called **pinnate** (Pl. II., fig. 3) when the leaflets are arranged in pairs along the rachis (or common petiole), and if the subdivision is carried further, the leaflets being pinnately arranged on secondary rachises, they are **bipinnate** (Pl. II., fig. 4), or even **3-pinnate.** Similarly, if several leaflets spring from one point at the apex of the petiole (Pl. II., fig. 7), they are called **digitate.** Digitate leaves are **3-foliolate, 5-, 7-,** or more **foliolate,** according to the number of leaflets.

This classification is convenient enough for ordinary purposes, but an examination of the figures in Plate II. will show that it is purely artificial. There are only two main plans or types of leaf-structure among the plants commonly met with, and these are governed by the venation or arrangement of the vascular framework of the leaf. Thus, in the plate figs. 1–4 represent a series of leaves in which there is a single midrib, which is the direct continuation of the petiole, and from which veins and veinlets are given off laterally. In each case the same form of skeleton or framework is represented, but the extent to which the green soft cellular tissue is developed is shown in four different ways by dotted outlines. Fig. 1 is that of a *simple entire* leaf, fig. 2 is *simple* and *pinnatifid*, fig. 3 is *compound* and *unequally pinnate*, while fig. 4 is *com-*

pound and *bipinnate*. Similarly, figs. 5–7 represent a series of leaves in each of which the petiole ends abruptly at the base of the leaf, while several ribs spring from the same point. Fig. 5 shows a *simple entire* leaf, fig. 6 is *simple* and *palmatifid*, while fig. 7 is a *compound* and *digitate* leaf.

Besides those which have been already described in the two previous chapters, the following are some of the terms used in describing the forms of leaves:—

Orbicular (or **rotundate**) when nearly circular in outline, as in *Pelargonium australe* (Pl. II., fig. 8).

Elliptical (or **oval**) when about twice as long as broad, and hardly tapering at either end, as in *Pomaderris elliptica* (Pl. II., fig. 9).

Oblong, much narrower than elliptical, but of the same general form, as in *Callixene parviflora* (Pl. II., fig. 10).

Linear when of nearly uniform breadth throughout, and many times longer than broad, as in *Panax lineare* (Pl. II., fig. 11).

Ovate, shaped like an egg, and with the broad end downwards, as in *Viola cunninghamii* (Pl. II., fig. 12).

Obovate, like an egg with the broad end up, as in *Hymenanthera latifolia* (Pl. II., fig. 13).

The term **spathulate** is applied to a somewhat thick fleshy obovate leaf usually without a distinct petiole, as in *Craspedia alpina* (Pl. III., fig. 1).

Cuneate,* or wedge-shaped, when tapering uniformly to the base, as in *Drimys colorata*, the Pepper-tree (Pl. III., fig. 2). (In the figure the leaf selected is nearly obovate, with only a cuneate base.)

Cordate, like a heart, with the sinus at the base, as in *Viola filicaulis* (Pl. III., fig. 3).

Obcordate, like a heart with the sinus at the apex, as in *Myrtus obcordata* (Pl. III., fig. 4).

Reniform, or kidney-shaped, as in *Trichomanes reniforme*, the kidney-fern (Pl. III., fig. 5).

Lanceolate, when narrow and shaped like a lance-head, as in *Melicytus lanceolatus* (Pl. III., fig. 6).

Oblanceolate, like an inverted lance-head, as in *Dodonæa viscosa* (Pl. III., fig. 7).

Sagittate,† shaped like an arrow-head, with the base produced downwards into acute lateral lobes, as in *Convolvulus sepium*, the Bindweed (Pl. III., fig. 8).

Hastate,‡ shaped like a spear-head, with the basal lobes directed outwards, as in Sheep's Sorrel, *Rumex acetosella* (Pl. III., fig. 9).

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* Lat. *cuneus*, a wedge.

† Lat. *sagitta*, an arrow.

‡ Lat. *hasta*, a spear.

PLATE. III.

1. Spathulate leaf of Craspedia alpina.
2. Cuneate ,, Drimys colorata.
3. Cordate ,, Viola filicaulis.
4. Obcordate ,, Myrtus obcordata.
5. Reniform ,, Trichomanes reniforme.
6. Lanceolate leaf of Melicytus lanceolatus.
7. Oblanceolate ,, Dodonæa viscosa.
8. Sagittate ,, Convolvulus sepium.
9. Hastate ,, Rumex acetosella.
10. Peltate ,, Ranunculus lyallii.

Peltate,* or shield-shaped : orbicular leaves, in which the petiole is attached to the under-surface instead of to the lower edge of the blade, as in *Ranunculus Lyallii* (Pl. III., fig. 10). These probably represent deeply-cordate leaves in which the basal sinus is closed.

In describing some forms of leaves it may be found that any one of the previous terms is not exactly suitable by itself, and then a combination of two terms may be used, as **linear-oblong, linear-lanceolate,** &c. ; or an adverbial prefix may be employed, as **broadly-elliptical.** Practice and comparison of leaves with the examples figured will alone enable you accurately to describe the forms of leaves.

There are many other terms besides those given which are employed by botanists, but those enumerated are most commonly used.

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* Lat. *pelta*, a target.

CHAPTER III.

6. Indian Cress, or Garden Nasturtium (*Tropæolum majus*).

This common plant, in one or other of its many varieties, is to be found in nearly every garden. Notice the lax straggling habit, the succulent stems and the peltate leaves, by whose petioles it appears to climb, though they are not nearly so sensitive as those of clematis. The surface is almost everywhere glabrous; but the plant is very efficiently protected against most insect and other enemies by its pungent juice. From this pungency it has received its common name of Indian Cress, and by a curious confusion of ideas (not uncommon with gardeners, who are seldom botanists) it has also come to be called Nasturtium, which is the generic name of *water-cress*, but is quite inapplicable to our present species.

The parts of the flower are easily made out. The calyx consists of 5 inferior sepals, connate at the base, of which the dorsal three unite to form a long spur or nectary. Of the 5 clawed petals 2 are **perigynous***—*i.e.*, they are fastened to the calyx. The three lower are hypogynous, smaller than the upper two, and have the lower part of the limb fringed with long coloured flat hairs. The 8 stamens are hypogynous, and have basifixed anthers.

If you notice a series of flowers, from those just opening to others which are commencing to wither, you will observe that after they have expanded, two or three of the stamens bend upward so that their anthers lie in the path of any insect entering the flower. After all their pollen has been shed the filaments bend down out of the flower, and other anthers—ready to dehisce—move up and take their place; so that for two or three days after opening any suitable insect visiting the flowers is almost certain to get dusted with pollen. After all the anthers have dehisced the style bends into the centre of the flower, and its stigma becomes viscid. By this contrivance self-fertilisation of the flower is rendered impossible. When first opened the flower is staminate in function, and later on it is pistillate only. This contrivance,

* Gr. *peri*, round about—the *gynæcium* or pistil; which is the literal meaning of the term.

by which the reproductive whorls mature at different times, is called **dichogamy**,* and flowers exhibiting this particular form of it (which is a common feature among a large number of ☿ plants) are said to be **protandrous**†—*i.e.*, their stamens mature first.

The ovary is 3-lobed and 3-celled, with a central style dividing at the top into three stigmatic branches. Cut the ovary vertically and transversely, and notice the single pendulous ovule in each cell.

When ripe the 3 carpels, which are indehiscent, fall away from one another, and the fruit is therefore termed a 3-partite schizocarp. At this stage the pericarp is more or less spongy or corky in consistence, the seeds have a somewhat tough testa, and, when opened, exhibit two thick cotyledons, concealing a short radicle, but having no endosperm.

(*a.*) Compare with this the Canary Creeper (*Tropæolum canariense*). Notice the pedate leaves (*i.e.*, shaped like a bird's foot) with their five lobes, and its flowers agreeing in all main points with the preceding, but differing considerably in details.

(*b.*) Examine the wild Geraniums, of which there are 4 species in New Zealand. Note the leaves, varying from orbicular in *G. molle* to palmati-partite in *G. dissectum* (Pl. I., fig. 4); the regular flowers, with 5 imbricate sepals, 5 petals contorted in bud, the 10 stamens arranged in two series, and the 5-lobed ovary. This ovary is the most distinctive feature of the genus. The 5 carpels are coherent by their inner edges, and have their styles prolonged into a beak, from which circumstance their common name of Cranesbill is derived, as well as their technical name *Geranium* (Gr. *geranos*, a crane). When ripe, the carpels separate away elastically from the base, and each splits up by its ventral suture. This is probably connected in some way with the distribution of the seed. The seeds are exalbuminous, and have thin, folded cotyledons. (The cultivated Geranium of the gardens is a greatly-hybridized plant belonging to the genus *Pelargonium*, and has its flowers always more or less irregular, and some of its stamens without anthers.)

Fig. 34. Fruit of *Geranium sessiliflorum*, before separation of the carpels (with calyx removed).

Fig. 35. Same, after the carpels have separated.

(*c.*) Various species of *Oxalis* (one is the plant called Shamrock) are to be found in gardens, and two grow wild in New Zealand. The structure of their flowers is not unlike that of *Geranium*. The 3-foliate leaves are singularly sensitive. At night each of the leaflets folds on its midrib and hangs down in a limp condition from the common petiole. This condition was called by Linnæus their sleep. If on a bright warm day, while the sun is strong on the plant, you shake it for a few seconds, you will find that in about a minute the same limp condition will be assumed.

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* Gr. *dicha*, in two parts; *gamos*, union.
† Gr. *protos*, first; *andros*, of a male.

(The leaves of a great number of plants close in the same manner at night—*e.g.*, clovers, lupins, acacias, &c.)

Fig. 36. Leaf of *Oxalis*, during the day.

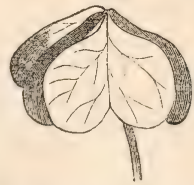

Fig. 37. Same, during sleep.

The fruit is a 5-celled capsule, the cells dehiscing along the back. Carefully observe the pendulous seeds. You will find that each one is covered with a fleshy-looking skin, and if you touch or scratch this with the point of a needle it will suddenly rupture and throw the seed out to a considerable distance. These plants are thus furnished with a most excellent means of seed-dispersion. On cutting the seeds longitudinally you will see that the embryo is not nearly so much developed as in Geranium, but is placed in the midst of fleshy albumen.

(*d.*) It will be advisable, if possible, to carry the examination of this series further, and get flowers and fruit of single Balsams (*Impatiens* sp.). The flowers are very irregular, the posterior sepal being produced into a large spur, and the others usually much reduced in size. The petals are apparently 3 in number, 2 on each side being united together. The 5 stamens have short flat coherent filaments, and lie close upon the ovary. The fruit is a 5-valved capsule. When nearly mature, take one of the capsules in your hand and gently press it, and you will observe the valves suddenly spring apart and coil up elastically. It is to this peculiarity that the generic name *Impatiens* is due.

7. Tutu (*Coriaria ruscifolia*).

This plant—formerly most abundant throughout the colony, but now exterminated in many of the more highly-cultivated districts—is a straggling shrub with weak 4-angled branches. The opposite leaves appear as if **distichous**,* or two-ranked, in their arrangement: this is due to the partial twisting of the internodes, the arrangement being in reality **decussate**.† Careless observers are apt to look upon the whole branch as a compound leaf with pinnate leaflets, but the occurrence of axillary leaf-buds is sufficient to disprove this mistake. Note the venation of the leaves with their 3 or 5 strong ribs. The inconspicuous greenish flowers are produced in elongated pendulous racemes in the axils of the lower leaves on 1-year-old branches; each flower has 5 sepals, 5 petals, 10 stamens (the inner 5 adnate to the petals), and 5 or 10 carpels. (Sometimes the symmetry is tetramerous or

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* Gr. *dis*, twice; *stichos*, a row.

† Having the opposite pairs placed at right angles, so that the leaves stand in four ranks on the stem.

hexamerous—*i.e.*, the parts of each whorl are 4 or 6 in number instead of 5.) Examine flowers just opening, and observe the 5 or 10 pink or red papillose styles projecting from each, while the immature anthers lie hidden inside. In the course of a

Fig. 38. Flower of *Coriaria* in first stage (mag.); *b*, bract.

Fig. 39. Flower of *Coriaria ruscifolia* in second stage.

few days you will notice that the styles wither; at the same time the filaments elongate so that the anthers hang loosely out of the flower and discharge a considerable amount of dry dusty pollen. The flowers are manifestly **anemophilous***—*i.e.*, fitted for wind-fertilisation—and are, besides, protected against the possibility of self-fertilisation by being **protogynous**†—viz., having the pistils maturing before the stamens.

The most remarkable thing about Tutu is the structure of its fruit. The carpels mature to achenes, each containing a pendulous seed with plano-convex cotyledons, while surrounding these are the five persistent petals, which become quite fleshy and full of a sweet purple juice when ripe. We have numerous examples of plants in which the whole or a part of the pericarp becomes succulent as a means for the dispersion of the seeds by birds, &c., and we shall also come across cases of succulent calyx- or perianth-leaves; but the Tutu is the only New Zealand plant in which the petals are modified to perform this function.

Note.—Many flowers are anemophilous, and the following features characterize them to a greater or less degree:—

a. Small size, the flowers usually in prominent positions on the plant, and frequently produced before the leaves.

b. Want of bright, conspicuous colours.

c. Neither scent nor nectar.

d. Relatively large and projecting styles, which are usually stigmatiferous all over.

e. Dry and dusty pollen, usually produced in very large quantity, and in anthers which are so hung as to be easily shaken.

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* Gr. *anemos*, the wind; *philos*, loved.

† Gr. *protos*, first; and the *gynœcium* or pistil.

Flowers which are **entomophilous**,* or insect-fertilised, are characterized by their being—

a. Conspicuous either individually or by aggregation;
b. By bright colours;
c. By the production of nectar or scent;
d. By the stamens and stigmas being relatively small, and usually included within the floral envelopes (not exserted); and, lastly,
e. By the quantity of pollen produced being comparatively small, and its consistence more or less granular or waxy, but not dusty.

8. Sweet Pea (*Lathyrus odoratus*).

We now come to the examination of a type which we shall find to be very common, and very constant in its characters.

This plant is a climbing herb, but it climbs in a manner different from *Clematis*—viz., by means of organs specially developed for the purpose, which are termed **tendrils**. A glance at the leaf will show what these organs are in this case.

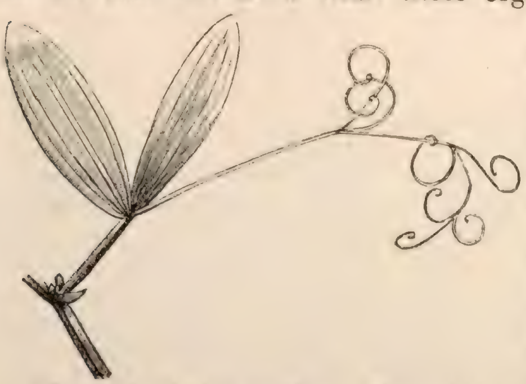

Fig. 40. Leaf of Sweet Pea, with tendrils (reduced).

The leaf is alternate and pinnate, and provided with small stipules at the base; but the lower pair of leaflets are alone developed, all the rest being reduced to midribs and acting as the climbing organs. It has been demonstrated (by Darwin and others) that these tendrils are not only sensitive to a slight irritation or to gentle pressure, curving in the direction of the touching body, but that they also perform a regular revolving movement, so that by one or other means they are brought into contact with objects on which they climb.

The stems and the rachis of the leaves are more or less broadly winged, the wings evidently performing some of the leaf-functions to make up for the loss of these in great part by the leaves themselves. The flowers are produced singly, or in twos or threes, on long peduncles which spring from the axils of the leaves. Note the 5-lobed inferior calyx, and the 5 irregular petals attached to the base of the calyx-tube (perigynous).

* Gr. *entoma*, insects; *philos*, loved.

Of these petals the upper, called the **standard**, enfolds all the rest in bud; while the two at the side, named the **wings**, enclose the inner two, which are more or less united by their edges to form the **keel**. From the fancied

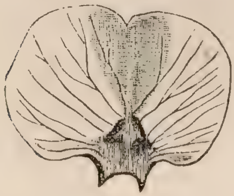

Fig. 41. Standard of Sweet Pea flower.

Fig. 42. Wing of Sweet Pea flower.

Fig. 43. Keel of Sweet Pea flower.

resemblance to a butterfly, such flowers as this are called **papilionaceous.*** On removing all the petals, observe the 10 stamens, also fastened to the base of the calyx-tube and forming a sheath to the ovary: 9 of them have their filaments united into a tube, while the one opposite the standard is free (= **diadelphous**).† The pistil consists of an elongated ovary, tapering into a style bent nearly at right angles, and ending in a minute stigma. On cutting the ovary transversely you will find it is formed of a single carpel, having a single row of ovules arranged along the ventral suture. If you have a pod to examine, you will see that it opens, when ripe, by both its sutures, and this form of fruit is called a **legume.**‡ The seeds are very easily examined, but the type is still better made out, on account of its size, in the bean (*which see*, p. 39).

On account of their extreme irregularity, bright colours, fragrance, and minute stigmas, we are justified in inferring that the flowers of this plant, and, indeed, all of the type, are fitted for fertilisation by insects. At the same time, a very large number of plants of the pea-tribe, and this species among them, seem to be quite fertile even when all insects are excluded from visiting the flowers.

(*a.*) Garden Pea (*Pisum sativum*).—Note the perfectly glabrous character of this plant, the two or three pairs of leaflets developed, and the relatively immense stipules, evidently intended to perform the leaf-work. And, correlated with this leaf-development, note the absence of the wings on the stems and petioles which are so characteristic of the Sweet Pea. The flowers and fruit differ only in slight details from the preceding.

(*b.*) Broom (*Cytisus scoparius*) differs (*inter alia*) in having its stamens monadelphous, a character common to a large number of papilionaceous plants. Whin (*Ulex europæus*) has its branches, and, in many

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* Lat. *papilio*, a butterfly.

† Gr. *dis*, twice; *adelphos*, a brother.

‡ Lat. *legumen*, pulse.

cases, its leaves also, reduced to spines; the pods burst elastically on bright sunny days, as do those of the preceding plant. Clovers (*Trifolium*) of various species have their flowers clustered into rounded heads or very short dense racemes; the pods are usually indehiscent.

Any or all of the following should be compared with the foregoing: Lupins (*Lupinus* sp.), Laburnum (*Cytisus laburnum*), Lucerne (*Medicago sativa*), *Robinia*, Vetches (*Vicia* sp.), Bean (*Faba vulgaris*), French Bean (*Phaseolus vulgaris*), *Dolichos*, &c.

(*c.*) *Clianthus puniceus*, the most gorgeous of New Zealand peas, has pinnate leaves, with many pairs of leaflets, and pendulous bracteate racemes of large crimson flowers. Note the cup-shaped 5-toothed calyx, the reflexed standard, and the very long acutely-pointed keel. You will find in this, as in many similar flowers, that the anthers shed their pollen into the end of the keel, which forms a tube in which the style lies.

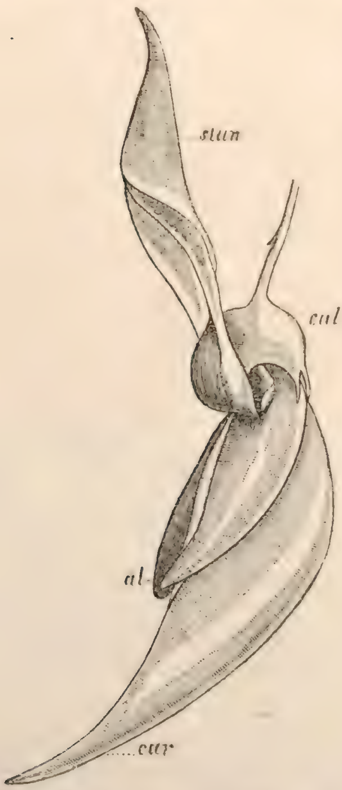

Fig. 44. Flower of *Clianthus*.

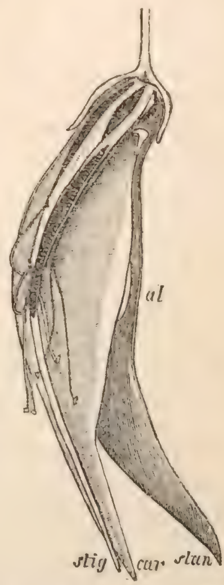

Fig. 45. Flower of *Clianthus*, in longitudinal section.

The lower part of the style is furnished with hairs which act as a brush, so that when the keel is forced back these hairs sweep out the pollen with considerable force. Try the experiment with a pencil-point. These flowers are chiefly visited by tuis and korimakos (honey-birds), which in this way probably fertilise them, for at the same time that the pollen is shot out, the point of the stigma projects. In this way the birds are constantly getting pollen on the feathers of the front of

the head, and transferring it on to the stigmas of other flowers. Notice that the pods open by one suture only.

(*d*.) Kowhai (*Sophora tetraptera*).—These trees, which are still common in many parts of New Zealand, though rapidly disappearing before the improving (?) hand of man, present features somewhat different from the normal type. Young plants are shrubby and have very flexuous branches, while the old ones form handsome trees. The leaves have sometimes as many as forty pairs of leaflets. The calyx is inflated, and its teeth are not very distinct. The petals are quite free, and

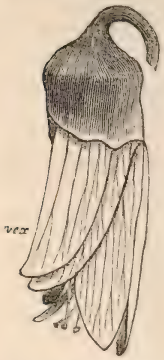

Fig. 46. Flower of *Sophora*.

Fig. 47. Standard (vexillum) of *Sophora*.

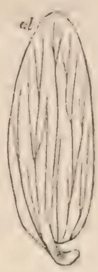

Fig. 48. Wing (ala) of *Sophora*.

Fig. 49. Keel (carina) of *Sophora*.

have nearly lost the papilionaceous character, while the stamens are quite free. The ovary is shortly stalked within the flower, but this feature becomes more marked in fruit. The pods are usually 3in. or 4in. long, tetrangular, and have their angles produced into 4 wings (hence the specific name); they are commonly indehiscent. The seeds are very hard and solid, and the cotyledons are not readily separable.

(*e*.) The structure of the exalbuminous seed of plants of this type is most conveniently studied in the bean. Place some dry beans in water for twenty-four hours or more, and when about to examine them dry them carefully without pressure. Observe the scar on one side by which each was attached to the funiculus; this is called the **hilum**.* If you now press the seed, you will observe at one end of the hilum that there is a small hole, the **micropyle**,† through which the contained moisture exudes. While the seed was still in the

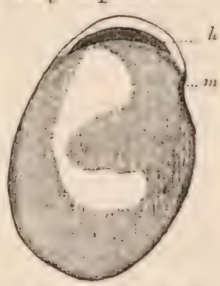

Fig. 50. Seed of Bean. (*h*, hilum; *m*, micropyle.)

* Lat. *hilum*, a little thing, a speck.
† Gr. *mikros*, small; *pule*, a gate.

ovule stage, the pollen tube, which fertilised it, entered by this opening. On removing the shell you will see that it is composed of two layers, the outer of which (the **testa***) is tough and thick, and the inner (or **tegmen**†) much thinner.

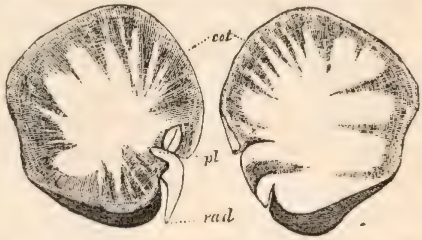

Fig. 51. Seed of Bean, with testa removed, after germination has commenced. (*cot*, cotyledons; *pl*, plumule; *rad*, radicle.)

In the ovule these two coats are termed respectively the primine and the secundine. The embryo is composed of two thick cotyledons, rounded on their outer and flat on their inner surfaces. The radicle, or root-bud, is situated on their margin, with its point lying just under the micropyle, while between them, near the same margin, is the **plumule**,‡ or stem-bud, with its rudimentary leaves already showing signs of development.

(*f.*) In the taller kinds of French Beans (Scarlet Runners, &c.) we see a mode of climbing different from any yet examined. These plants are **twiners**, and always twine in one direction only. In a seedling plant the first internode usually stands erect, but, owing to the rapid and unequal growth of the apex of the stem, the second and succeeding internodes curve to one side, and, as this curvature continually changes its position, the apex of the young stem moves regularly round in a circle or ellipse. If an upright support such as a stick be interposed at a little distance below the apex, the latter continues to move round it, and in this way makes a series of revolutions on it, or, in other words, twines round it. In the French Bean, as in the majority of twining plants, the twining is from left to right—that is to say, that as you stand facing the plant the stem passes round the front of the support from your left to your right, and round the back from right to left. A few plants—*e.g.*, the hop—twine in the opposite direction; but the noticeable feature is, that each plant has its specific direction, and no coercion will make it twine in a different manner from that which is natural to it.

* Lat. *testa*, a shell.
† Lat. *tegmen*, a covering.
‡ Lat. *plumula*, a little feather.

It will be advisable at this point to examine, if possible, one or two kinds of Wattles (*Acacia* sp.); but it is difficult to fix upon any one as a type, as so many kinds are to be found in cultivation. Most of them have compound leaves, either pinnate or bipinnate, with numerous small leaflets; but in very many species the petioles become broad and leaf-like, and take the place of the leaves, and are then termed **phyllodes**.* They can generally be distinguished by having no distinct upper and under surface, and by hanging with their edges vertical. Sometimes they are reduced to spines. The flowers are very small, and are usually crowded into small heads, which again are arranged in more complex inflorescences. They are best examined before they are fully open. The 4–5-lobed calyx is valvate in bud; the petals (which are similar in number) are more or less united together (= gamopetalous), and are also valvate in bud. The stamens are very numerous, and have their filaments often united at the base. Lastly, the ovary is 1-celled, and ripens into a legume.

Fig. 52. Phyllodia and stipular spines of *Acacia armata*.

9. Bush Lawyer, or Native Bramble (*Rubus australis*).

In this rampant straggling shrub we see another development of that climbing habit which has been so commonly assumed by many plants, and of which we have considered examples in the Clematis, Indian Cress, Pea, and French Bean. But in this species, while the young shoots have probably a slight twining habit, the climbing is chiefly accomplished by the recurved hooks on the back of the petioles and midribs. These hooks are only developments of the skin, or epidermis, just as we see in the Rose; but their function is more evidently specialised. Note how the main petiole, as well as the secondary petioles, are sharply bent near their extremity, to enable the hooks to take a better hold. The downward curvature of the spines enables the stems and leaves to slip readily *up* a support, but they are not easily pulled *down*. Try the experiment on the sleeve of your coat. The leaves are digitate, and either 3- or 5-foliolate, and the shape of the leaflets is extremely variable (in one variety they are reduced to midribs only). Note how the stipules are completely **adnate** to the petiole (*i.e.*, are joined by their whole length), their tips only being free.

The flowers are diœcious (very rarely ☿), and are arranged in large panicles.

♂ *flowers*.—The panicles are very large, and the flowers are powerfully fragrant. Note the 5 sepals united below to form with the receptacle a flat disc, which is frequently thickly covered with nectar; the 5 rounded concave petals placed on the edge of the disc, imbricate in bud and very deciduous; and the ∞ stamens, attached in two or three whorls just inside the

* Gr. *phyllon*, a leaf.

petals (=perigynous). The ovary is totally undeveloped, the only trace of the pistil being a red papillose point in the centre of the disc, and which apparently represents the stigmas of the undeveloped carpels. The nectariferous disc attracts numbers of flies, beetles, and other insects.

Fig. 53. ♂ flower of *Rubus australis.*

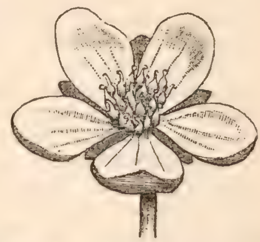

Fig. 54. ♀ flower of *Rubus australis.*

♀ *flowers.*—The panicles are usually smaller, and the individual flowers are smaller and greener than the ♂. The adhesion of the calyx—which could not be made out in the ♂ flowers—is here seen to be inferior; the petals are generally similar, the stamens are totally wanting, while the ovary is formed of a large number of closely-packed, but separate, carpels. Each carpel bears a small sub-apical style, which expands into a more or less oblique stigma. Make a longitudinal section, and notice that each carpel contains a single pendulous ovule.

Later in the season try to get these carpels as they progress towards maturity, and observe the modifications which they have undergone. Each one has become succulent, forming a little fruit called a **drupel**, the structure of which will be more easily understood when you have examined the fruit of a peach or plum. When quite ripe all the division-walls between the separate drupels disappear, and the whole form together the succulent aggregate fruit known as the bramble- or lawyer-berry.

Fig. 55. Fruit of N.Z. Bramble.

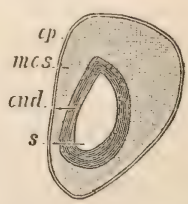

Fig. 56. Drupel of N.Z. Bramble, in longitudinal section. (*ep*, epicarp; *mes*, mesocarp; *end*, endocarp; *s*, seed.)

(*a.*) Compare the Raspberry (*Rubus idæus*) with the preceding, and notice how—though the plant is a perennial—its stems are biennial, coming up one season, bearing flowers and fruit the next, and then dying. The hairs on the stems are not developed into spines, the plant not being a climber. The flowers are ☿, not diœcious.

(*b.*) The Sweet-briar Rose (*Rosa rubiginosa*).—Note the straggling stems (becoming almost climbing in some cultivated roses), armed with woody spines, which, however, are hardly at all recurved. The object of these spines and similar growths is probably to protect the plants against the attacks of grazing animals. The leaves, as in the raspberry, are pinnate, and have adnate stipules. Compare two flowers, one entire and the other cut longitudinally. Notice that the lower part of the 5-lobed calyx unites with the receptacle to form an inflated sac, in which the carpels are placed, and that this is the part which in fruit becomes crimson and succulent. Any fruit formed, as this is, of the pistil together with some other part, is termed a pseudocarp;* and if we cut open a rose-hip, as the ripe pseudocarp is called, we find that the separate and ∞ carpels have ripened into achenes. Evidently the object in this case, as in that of the raspberry and bramble, is to render the fruit attractive to birds, and perhaps to some animals. These swallow the achenes, and pass them through their alimentary canal unharmed and ready to germinate. In this manner the seeds are distributed. But, while in *Rubus* it is the outer part of the pericarp of each little carpel which becomes succulent and brightly coloured, in the rose the pericarp of each carpel remains hard and dry, and the receptacle and calyx-tube combine to form the attractive portion. Thus the same end is gained, but by the employment of different means.

Fig. 57. Pseudocarp of Rose, in longitudinal section.

(*c.*) In the Strawberry (*Fragaria vesca*) a common mode of propagation is by long creeping stems or *runners*, which send down roots at the nodes. The rose, and many other plants of the family, also increase by similar stems, which, however, creep along under the surface of the ground, and are termed *suckers*. The flowers are very similar to the preceding, having, however, a double calyx of 10 sepals. Note the development of the fruit. You will observe that the receptacle in this flower continues to swell up until it becomes the large succulent mass we know as the strawberry, *on the outside of which* the achenes are placed. These, of course, are popularly called the seeds, but if you cut one longitudinally you will find it contains a single seed inside.

Fig. 58. Achene of Strawberry with lateral style (mag.).

Fig. 59. Longitudinal section through achene of Strawberry (mag.).

(*d.*) Piripiri (*Acæna sanguisorbæ*).—This plant, whose name is usually pronounced "bid-a-bid," is a familiar friend. Most people are only familiar with its ripe fruit, and consider it a pest. Note the strong, tough, creeping, silky stems, the remote alternate leaves, with their adnate stipules, their numerous pinnate leaflets, which diminish in size from the terminal one to those at the base, the deeply-serrate margins,

* Gr. *peudos*, false; *karpos*, fruit.

and the silky surfaces. The small flowers are crowded into globular heads placed on long penduncles. Get them, if possible, at all stages of development. In flowers just opened note the 4-angled and 4-lobed calyx, which is generally covered with bristle-like hairs, while from each angle there

Fig. 60. Flower of *Acæna*, in longitudinal section.

Fig. 61. Spine of calyx of *Acæna*.

rises a stiff green spine with several barb-like reversed hairs at its apex. The calyx-tube is applied so closely to the ovary as to appear almost adnate to it, while attached to its upper portion are the 4 petals, which are slightly united at the base to form a 4-lobed imbricate corolla. The stamens are usually 3 or 4 in number, sometimes fewer, sometimes more, on rather long slender filaments. The ovary contains 1 pendulous ovule, and bears a flattened plumose stigma. When nearly mature the ovary will be found to have ripened into an elongated achene, closely enclosed in the hardened calyx-tube, and having its spines also elongated and hardened, forming the well-known appendages or burrs, by means of which the seeds are distributed.

(*e.*) The Apple (*Pyrus malus*) presents a modification of the rose-structure. First, note that the leaves are simple, and furnished with free deciduous stipules. The chief difference, however, is in the fruit. In this the adnate calyx-tube (with which is probably united the enlarged receptacle, as in the rose) becomes succulent, forming the edible portion of the fruit, and enclosing the 5-celled ovary, while the withered remains of the 5 calyx-lobes remain persistent on its summit. This form of fruit (pseudocarp) is called a **pome**.† (In the apple the pericarp (or core) is horny or cartilaginous; only membranous in the pear: while in Hawthorn it is almost bony.) Compare with the foregoing Quince, Medlar, and *Cydonia japonica*.

† Lat. *pomum*, an apple.

(*f.*) The Plum (*Prunus communis*) and Cherry (*Prunus cerasus*) exhibit a further difference in the ovary. Each flower has an ovary of one carpel containing 2 pendulous ovules, of which only one, as a rule, ripens. In ripening, the pericarp undergoes considerable change. The inner layer (**endocarp***) becomes very hard and bony, forming the stone or **putamen**† of the fruit; the middle layer (**mesocarp**‡) becomes succulent, and is the edible portion; while the whole is covered by an outer skin (**epicarp**§). This form of fruit, in which a hard inner layer of the pericarp is covered by a succulent pulp, is called a **drupe**. The object of this development is most probably to render the fruit attractive to birds, which in eating them must sometimes swallow the stones; and these, resisting the digestive action of the stomach, pass uninjured through the alimentary canal. In this way wide distribution of the seeds is effected. In the case of the larger drupes it is sometimes the case that birds carry the fruit away to a quiet spot, often at a considerable distance, where they pick off all the edible portion and reject the stone, which is thus left at a greater or less distance from the parent tree. (Compare also Peach, which is here figured, Nectarine, Apricot, Cherry Laurel, or Almond, in the latter of which the pericarp is dry and fibrous.)

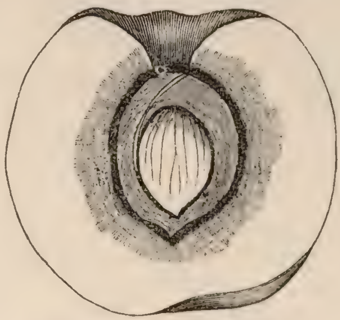

Fig. 62. Fruit of Peach.

10. Manuka, or Tea-tree (*Leptospermum scoparium*).

Note the rigid erect habit of this common shrub; and the pale-greyish or light-brown bark, which is readily shed off old specimens in long strips. The small alternate exstipulate leaves stand nearly horizontally from the stem; their hard entire margin runs into a hard, almost spiny tip (such an apex is said to be **mucronate**‖). Examine them between the eye and the light by means of a lens, and you will see that they are marked all over with small pellucid dots, which are the so-called oil-glands.

The flowers are solitary and sessile at the ends of short branches. You will find that they are sometimes ☿, but even more frequently polygamous, the former being often associated with ♂ flowers. Note the hemispherical calyx-tube, with its 5 rounded deciduous superior lobes; the 5 orbicular imbricate petals placed on the edge of the calyx-tube; the ∞ free stamens fastened just within the petals, and curved inwards in the buds; and the single style crowned with a small capitate or button-like stigma. In transverse section the ovary is seen

* Gr. *endos*, within; *karpos*, a fruit.
† Lat. *putamen*, a shell or pod.
‡ Gr. *mesos*, middle; *karpos*, a fruit.
§ Gr. *epi*, upon; *karpos*, a fruit.
‖ Lat. *mucro*, a sharp point.

to be 5-celled, and to contain a great number of ovules, which hang from the inner upper angle of each cell.

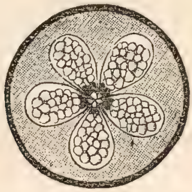

Fig. 63. Ovary of Manuka, transverse section.

Fig. 64. Capsule of Manuka, longitudinal section.

On the same plant which bears the flowers you will probably find last year's fruit. The calyx-tube is still present as an inferior woody cup half-enclosing the ovary, the upper portion of which opens loculicidally by 5 valves. The seeds are very small and linear.

A second species of Manuka (*L. ericoides*) is very abundant in many parts of New Zealand, sometimes occurring along with *L. scoparium*. It is readily distinguished by its smaller, softer, and more crowded leaves, which are not mucronate, and by the smaller, always ☿ flowers, placed on short pedicels, and having a more elongated calyx-tube, which in fruit encloses the whole capsule.

(*a.*) Compare with this type any of the Ratas, Ironwood-trees, or Pohutukawas which grow in your neighbourhood, all of which belong to the genus *Metrosideros*. In some of the climbing species the leaves are arranged in two ranks (= distichous), giving the branches the appearance of pinnate leaves. In the flowers note particularly the elongated stamens, which in some species are the most conspicuous feature. Some of these ratas depend upon birds for their fertilisation. While the sepals and petals are 5 in number, and the capsule is often 5-ribbed, it will be found that the ovary is only 3-celled, and when mature opens by 3 valves.

Fig. 65. Flower of *Metrosideros florida.*

(*b.*) Compare also the Myrtles (genus *Myrtus*), of which we have four New Zealand species. In these the ovary is usually only 2-celled, and ripens to a berry, containing a few seeds which have a hard testa.

(*c.*) In nearly every part of New Zealand species of *Eucalyptus*, or Australian gum-trees, have been planted. Of these, *E. globulus*, the Blue-gum, is the most familiar. Note the following among other characters: (1) The oblique venation of the leaves, which have no upper and under surface, but hang vertically; (2) the thick—almost woody—calyx-tube, which is sometimes 4-angled, and usually shows no trace of lobes;

(3) the petals apparently wanting altogether, but probably cohering together to form the lid or operculum, which covers the flower in bud, and which falls off entire when the stamens are ready to expand; and (4) the hard woody capsule. In most other characters the relationship to *Leptospermum* is manifest.

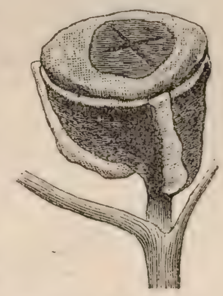

Fig. 66. Capsule of Blue-gum.

Seedlings and young trees always have the leaves opposite, and oblong or cordate in shape. The midrib is in or near the middle of the leaf, and the latter has a distinct upper and under surface. As the plant gets older, however, the leaves become narrower, the midribs are seen to be more and more oblique, while the blades gradually pass into the vertical position. It is probable that this turning of their edges to the sun lessens the evaporation of water which takes place from the surface of the leaves, and thus enables these plants better to withstand the long droughts of Australia. The effects produced by gum-trees when growing are very easily observed. Their deep and widespread roots dry up the ground underneath and around them, while at the same time their leaves do not cast much shade. The result is that very few plants can grow under them, on account of the dryness of the surface-soil which they thus produce.

11. Fuchsia (*Fuchsia excorticata*).

The structure of the leaves and flowers of this plant is very simple and manifest, but there are many interesting features about it worth noting. Observe in old specimens the papery deciduous bark from which it takes its specific name, and the simple alternate leaves with just the faintest traces of stipules at the base of the petiole. In many of the colder parts of the colony the leaves are deciduous, and this is the only indigenous plant which shows this character, which is so common a feature of the trees and shrubs of the Northern Hemisphere. The flowers are pendulous, and are of two (sometimes three) kinds (found on different plants); one—by far the commonest—large and of a dark-green or purplish colour; the other much smaller and of a pale-pinkish hue. Take the commoner form, and note that the lower part of the calyx-tube is adnate to the inferior ovary, but that it is produced much beyond it, and is ultimately divided into 4 lanceolate acuminate lobes, which are valvate in bud. The portion of the tube immediately above the ovary is dilated into a globular nectary. At the bases of the calyx-lobes, and inserted between them, note the 4 small purple petals. Below these, but also inserted on the calyx-tube, are 8 stamens, 4 short ones alternate with, and 4 longer opposite, the lobes. The large anther-cells contain masses of *bright-blue* pollen-grains, which are tied together by numbers of extremely delicate threads. Lastly, note the 4-celled ovary with its numerous ovules, the long slender style, and the rounded or 4-lobed

stigma. The flowers are perfectly symmetrical in the number of their parts.

Now look for the small-flowered kind. You will find that the structure is very similar to that of the large form, with one important exception—namely, that the anther-cells contain no pollen. So, while both kinds are ☿ in structure, the smaller form is only ♀ in function.

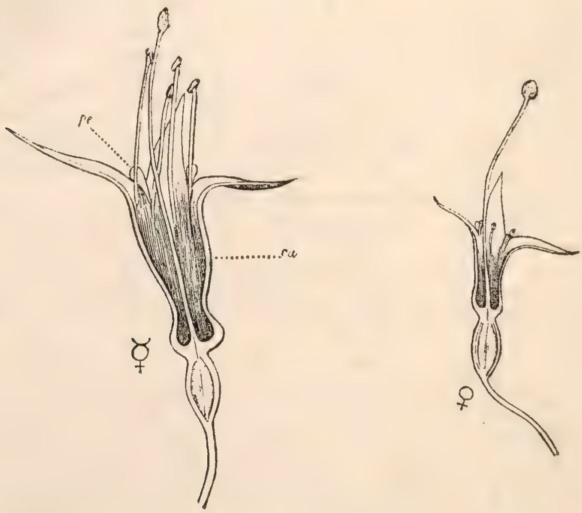

Fig. 67. Flowers of *Fuchsia excorticata*, showing both large and small kinds. (*ca*, calyx; *pe*, petals.)

It is worth while to watch a tui or honey-bird (korimako) when busy among the fuchsia-flowers, and you will see how they are fertilised. You will also understand why the flowers are pendulous, why the filaments and style are so long and the pollen so much tied together, and why there is such a large quantity of nectar produced at the base of the long tube. By closely watching you may easily see that the feathers immediately above the bird's bill are smeared over with the blue pollen.

The fruit, which ripens from January to March, is a berry —*i.e.*, a fruit in which all the layers of the pericarp have become succulent. The object is evidently the same as that aimed at in the structure of the fruit of the bramble, rose, strawberry, &c. — namely, that birds may be tempted to swallow them, and thus distribute the seed.

(*a*.) Compare with these flowers those of garden or greenhouse fuchsias, which are hybrids of South American species. They differ chiefly in the much brighter colours of the calyx and the greater development of the petals, which are convolute in arrangement. Also try to get hold of the pretty

little *Fuchsia kirkii*, a native of the Great Barrier Island, but which is now to be found in cultivation in many gardens. Notice the beautiful little flowers, brimful of nectar and quite destitute of petals. The berry is large, pink or purplish-red, with the cells hollow in the centre, and containing very numerous seeds.

Fig. 68. Flowers of *Fuchsia kirkii*.

Fig. 69. Flowering branch of *Epilobium nummularifolium*.

(*b*.) In the native species of *Epilobium* or willow-herbs, the long inferior ovary ripens into a slender linear capsule opening throughout its whole length by 4 valves, which become ultimately recurved and often twisted. The little seeds lie in a single row within each valve, and each one is furnished at the apex with a tuft of fine silky hairs, forming an apparatus which enables the wind to scatter it.

Fig. 70. Longitudinal section of *Epilobium*.

Fig. 71. Capsule of *Epilobium*.

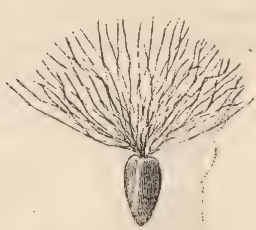

Fig. 72. Seed of *Epilobium*.

(*c*.) Compare with this type the flowers of *Godetia*, *Clarkia*, or *Œnothera*, which are so commonly to be found in gardens. Note the differences in the fruit.

12. PARSLEY (*Carum petroselinum*).

This plant may be taken as a type of a strongly-characterized group called *umbelliferous* (*i.e.*, umbel-bearing) plants: it has the advantage of being found in every garden.

Note the herbaceous habit, the strong rank odour (especially when the plant is crushed), the grooved stems, and the alternate much-divided leaves. These are tri-pinnate; the main petiole bearing a secondary set of petiolules, and these a third on which the leaflets are pinnately arranged. They are mostly radical, springing from near the base of the plant, and their petiole forms a sheath to the stem. Of course, in Parsley, cultivation has tended to make the leaves very compound, as the plant has been improved (from the cultivator's point of view) by always selecting the most curled varieties; so that we here see a natural tendency to subdivision of the leaflets greatly exaggerated by artificial selection.

The small flowers are arranged in a very characteristic form of inflorescence. Each flower has a short pedicel, and from 10 to 20 of these spring from the apex of one common stalk or peduncle. These, again, are similarly arranged on the apex of the branches. Such an inflorescence is called a **compound umbel** (each of the smaller groups being a simple umbel), and it gives its name to the whole group of plants characterized by possessing it. Note that the leaves on the flowering-stems become more and more reduced in size and number of leaflets the higher up they go. Under each umbel is a circle, or **involucre**,* of very small leaves (bracts); and again under each secondary umbel is another circle, called in this case an **involucel.** The peduncles, or **primary rays** of the umbel, are about $\frac{1}{2}$in. long, while the pedicels, or **secondary rays**, vary from $\frac{1}{10}$in. to $\frac{1}{8}$in. All of these become longer after the flower has withered and as the fruits are approaching maturity.

Fig. 73. Flower of Parsley (long. section).

Examine the flowers with care, and compare them with the fruit. In the former it is difficult to make out the calyx completely, but in the latter it is seen that the tube is adnate to the ovary, the limb being only developed as a slight ring. The 5 petals are placed on the top of the ovary, at the margin of the calyx-tube (= **epigynous**† adhesion), and have their tips inflexed towards the centre of the flower. The 5 stamens, which stand alternately with the petals, are also curved inwards; the anther-cells are very

* Lat. *involucrum*, a wrapper.

† Gr. *epi*, upon—the *gynœcium* or pistil.

short and broad. On the top of the ovary, mark the yellow epigynous 2-lobed disc or **stylopod**,* from the division of whose lobes the 2 curved styles are produced. Make transverse and longitudinal sections of the ovary: you will find it is 2-celled, and that each cell contains a single pendulous ovule. If it is late enough in the season you will find the fruit ripe, or nearly so, at the same time as the later flowers. The cells of the ovary have now become considerably enlarged and slightly curved outwards from one another, and they

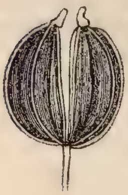

Fig. 74. Fruit of Parsley.

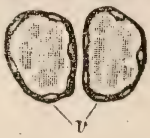

Fig. 75. Fruit of Parsley (trans. section). v = vittæ.

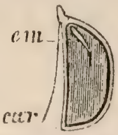

Fig. 76. Fruit of Parsley (long. section). *em* = embryo; *car* = carpophore.

exhibit 5 slightly-projecting longitudinal ridges. When quite mature they finally separate, but remain attached to one another by two very slender stalks, which are united below and form the **carpophore**.† Cut a carpel transversely, and notice that between each of the ridges lies a flattened channel or tube: these tubes are the oil-canals, or **vittæ**,‡ and it is probably to the volatile oil contained in them that the powerful aromatic smell of the seed is due. In longitudinal section you will see that the seed adheres very closely to the pericarp, and that it is full of a dense endosperm, towards the upper end of which lies the small embryo.

Fig. 77. Unripe fruit of *Apium australe*.

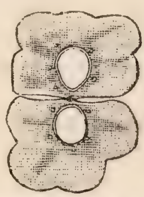

Fig. 78. Fruit of *Apium australe* (trans. section), showing the oil-canals.

(*a*.) There are many other plants which may be examined instead of or along with Parsley—*e.g.*, Celery, either the cultivated plant (*Apium graveolens*) or, still better, the two new Zealand species (*A. australe* and *A. filiforme*), which are both common along many parts of our sea-coasts; Carrot (*Daucus carota*), or the New Zealand species (*D. brachiatus*), in which the carpels have nine ridges covered with short hairs or spines; Fennel (*Fœniculum vulgare*), which is a very common weed in many parts, particularly of the North Island; and Parsnip (*Pastinaca sativa*).

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* Gr. *stulos*, a style; *pous*, *podos*, a foot.
† Gr. *karpos*, fruit; *phoreo*, I bear.
‡ Lat. *vitta*, a band or fillet.

(*b.*) Of indigenous species there is considerable variety, and species of *Hydrocotyle** (with simple rounded leaves and flowers in simple umbels), *Ligusticum*, and *Angelica* are common. The most striking form, however, is the Spear-grass, belonging to the genus *Aciphylla*. Five species are known in New Zealand. In all of them the leaves are once or twice pinnate, and the leaflets, together with the involucral bracts, are spiny. The umbels are not flat-topped as in most of the cultivated umbellifers, but are crowded into more or less dense panicles; and the flowers are diœcious or polygamous.

Fig. 79. Part of ♀ inflorescence of Spear-grass — *Aciphylla colensoi.*

Fig. 80. Fruit of Spear - grass (mag.).

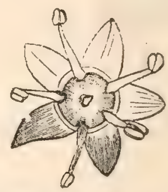

Fig. 81. Flower of *Panax arboreum.*

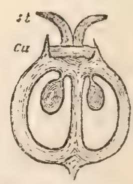

Fig. 82. Longitudinal section of ovary of *Panax.*

Somewhat closely allied to umbelliferous plants are the various species of *Panax* (Grass-tree, New Zealand Gum, &c.). They differ not only in their arboreous habit, but in usually having more than two cells in their ovary. The fruit does not split up into its separate carpels, and remains somewhat fleshy when mature.

Structure and Modes of Dehiscence of the Fruit.

In describing the buttercup and all the plants subsequently examined we have spoken of the carpels as modified leaves, but no attempt has yet been made to show how this leaf-structure can be made out in those ovaries which are composed of several such carpels. Let us again examine the pod (legume) of a pea, which exhibits the simplest form, and is composed of

* See fig. 173, p. 88.

one carpel only. If this is split open a row of ovules is seen along one of the edges. This portion is called the ventral suture of the carpel, and represents the margins of the carpellary leaf; while the back of the pod is termed the dorsal suture, and represents the midrib. If you cut out a piece of paper of the form shown in the figure,* marking it in the manner indicated, and fold the two edges together, you will obtain a rough model of a pea-pod, and will see that the legume is only a leaf with the two sides of the blade folded together. A section through this carpel would present something of this appearance, in which *ds* represents the midrib, or dorsal suture, and *vs* the infolded margins, or ventral suture. Wherever, in any ovary, we find the ovules we have a clue to the position of (at least a portion of) the ventral sutures of the carpels composing it.

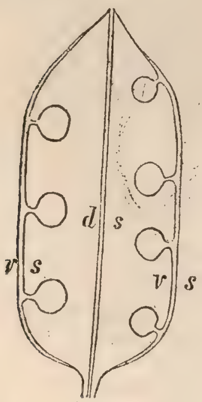

Fig. 83. Diagrammatic figure of a simple carpellary.

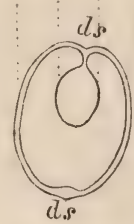

Fig. 84. Carpellary leaf in transverse section.

Now take three pieces of paper of a somewhat similar form, and, folding a thin strip of the margins inwards, fasten (by pins or otherwise) the three together, edge to edge. You will thus get a rough representation of such an ovary as occurs in the violet —viz., 1-celled, with three *parietal* placentæ. This is clearly made up of three united carpellary leaves, the placentæ (*vs*) marking the line of union (or the ventral sutures) of two adjacent carpels; the midribs (*ds*) being half-way between these points.

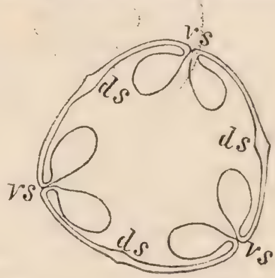

Fig. 85. Transverse sections of three carpellary leaves; their margins united to show parietal placentation.

Next take two or more large pieces of paper of the form originally shown, and first make a fold at right angles down the direction of the dotted lines; then fold the margins together as in the model of the pea. If now you fasten the

* The form best suited to show this is most readily ascertained by practice. No model cut out of a sheet of paper can do more than show this structure very approximately.

sides of these artificial legumes together you will get a model showing approximately the structure of a 2- or more-celled ovary with *axile* placentation. In this it is clear that the margins of the carpellary leaves all meet in the centre, or axis, of the ovary; that the midribs are

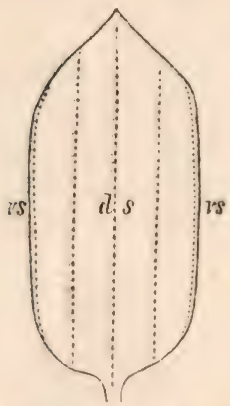

Fig. 86. Form of paper model of carpellary leaf.

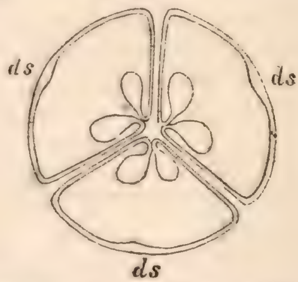

Fig. 87. Three carpellary leaves folded so that their margins meet in the centre.

at the points marked *ds*; and that each dissepiment is made up of portions of the blades of two adjoining carpellary leaves. In many cases these dissepiments have either wholly or partially disappeared, and then we have a 1-celled ovary with *free-central* or *basal* placentation (the dotted lines indicating where the septa have been).

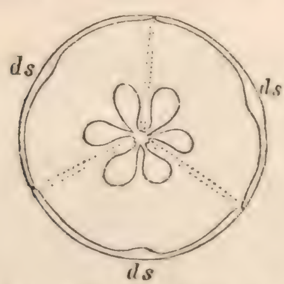

Fig. 88. Transverse section of three carpellary leaves, their margins meeting in the centre and their dissepiments absorbed, thus producing free-central placentation.

Now, if we have a clear idea of this derivation of syncarpous pistils from modified leaves which bear the ovules on their margins, we are in a better position to understand the mode of dehiscence of various fruits. It has been stated already that a number of fruits are indehiscent — *e.g.*, nuts, drupes, berries, &c. — and in these the seeds are liberated by the decay of the pericarp; but a large section of dry fruits dehisce, and thus scatter their seeds, and it is to the mode in which this is brought about that we will now address ourselves. The simplest form of dehiscent fruit is, as we have seen, the *legume*, in which the carpel splits along both sutures: only one legume is produced by each flower (p. 37). The *follicle* is likewise composed of a single carpel, which splits along the ventral suture only: two or more follicles always result from

each flower (p. 15). A 2-celled fruit having its seeds on parietal placentæ, and which is divided by a false dissepiment, or replum, is called a *siliqua* or *silicula* (p. 18), and it opens by the whole valve on each side falling away from the placentæ. Here the dehiscence is manifestly at the ventral sutures, the valves representing the whole of the carpellary leaves except the extreme margins, which are persistent. It is manifest also from this that the replum of the siliqua is not the same morphologically as the dissepiment of any other 2-celled ovary—viz., part of the blade of two cohering carpellary leaves—but is instead a production of the substance of the placentæ.

All other forms of dehiscent fruits are termed *capsules*, but the manner of their dehiscence varies. The following are the chief modes :—

1. By **teeth**, as in Chickweed (p. 24). Here there are 3 carpels united into a 1-celled ovary with free-central placentation, and the capsule dehisces by 6 teeth. It can be easily seen on examination that three of these teeth represent the dorsal sutures of the carpels, and 3 the lines of the suppressed dissepiments. Another excellent example is furnished by the Primrose, where a capsule made up of 5 carpels dehisces by 10 teeth.

2. By **valves** ; and this valvular dehiscence usually follows one of three modes :—

a. **Loculicidal,*** when the dehiscence takes place at the dorsal sutures of the carpels, and the walls fall out, carrying the dissepiments with them (p. 90).

Fig. 89. Diagram of loculicidal capsule.

Fig. 90. Capsule of *Libertia*, with loculicidal dehiscence.

Fig. 91. Diagram of septifragal capsule.

b. **Septifragal,†** where the dehiscence takes place at the junction of the wall and the dissepiments, and the former falls out, leaving the latter standing. as in Rhododendron.

c. **Septicidal,‡** where the dehiscence takes place at the ventral sutures, so that the original carpels fall away from each other (p. 71).

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* Lat. *loculus*, a little place ; *cædo*, I cut.
† Lat. *septum*, a division ; *frango*, I break.
‡ Lat. *septum*, and *cædo*.

In 1-celled ovaries such as those of Violet it is only usual to call the dehiscence *valvular:* in this case it is clear that it takes place at the dorsal sutures of the carpels.

Fig. 92. Diagram of septicidal capsule.

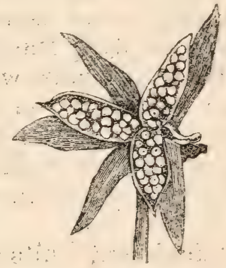

Fig. 93. Capsule of Violet, showing valvular dehiscence.

Fig. 94. Capsule of Mignonette, opening by a terminal pore.

3. By **pores**, which originate in different ways. In mignonette the carpels forming the 1-celled ovary are never in very close contact above, so that the capsule when ripe presents

Fig. 95. Capsule of Poppy, dehiscing by pores.

Fig. 96. Capsule of Snapdragon.

Fig. 97. Circumscissile capsule of Pimpernel.

(by the shrinkage of the pericarp) one large aperture or pore. In Poppy the stigma remains sessile and the pericarp shrinks away from below it, leaving a row of pores. In Frogsmouth (p. 70) small openings form at the apex of the cells of the ovary as the fruit ripens.

Fig. 98. Circumscissile capsule of Plantain.

4. By **transverse** or **circumscissile** dehiscence. Here, as in pimpernel (p. 66) or plantain (p. 74), the upper portion of the pericarp separates off as a lid, which has apparently no connection with the carpellary structure of the ovary.

CHAPTER IV.

13. Ox-eye Daisy, or Marguerite* (*Chrysanthemum leucanthemum*).

We may take this familiar flower as a type of that largest group of flowering plants termed composites.

We will proceed at once to examine the flowers; and the first point to notice is that the thing we usually call the flower is in reality a cluster of small sessile flowers (called **florets**) densely crowded together on a common receptacle. If these florets were scattered along a rachis they probably would not make so conspicuous an object as they do when crowded together, but—as if in order to economize space as much as possible, and to make them readily seen—they are all produced on one level (or only slightly convex) surface, *the common receptacle*. This form of inflorescence is called a head,

Fig. 99. Capitulum of Ox-eye Daisy.

Fig. 100. Capitulum of Ox-eye Daisy from the back, showing involucral bracts.

* In this case, as in that of other type-plants selected, one of the numerous other forms mentioned afterwards may be substituted, taking care to notice minor differences.

or **capitulum**.* Each head is surrounded by a calyx-like *involucre* of purple-edged bracts. In order still further to make the heads conspicuous, the florets of the outer row have their corollas specially modified, so as to differ not only in shape, but also in colour, from those within: these white outer florets form the **ray**, and the yellow inner ones the **disc**, of the flower-head. We must examine each kind in detail.

Each **ray-floret** consists of an inferior ovary, a white corolla, and a 2-branched style. The calyx appears at first to be quite wanting, but its tube is in reality adnate to the ovary, while the merest trace of a ring above the ovary is all that can be seen of the limb. The corolla is all in one piece—*i.e.*, its component petals are joined together (=**gamopetalous** or **synpetalous**†)—and, beyond having a slight notch at the apex, there is nothing to show how many petals it is composed of. The lowest portion, just above the ovary, is in the form of a tube, but the greater part of it is spread out into a flat limb, giving it the characteristic strap-like shape from which its name **ligulate**‡ is derived. Note that its adhesion is epigynous. There are no stamens in this flower, but from the middle of the top of the ovary arises a single style, dividing into two branching arms. The flowers therefore are ♀ in structure. Make a longitudinal section of the ovary, and notice that it is 1-celled and contains a single erect ovule. When the fruit is ripe you will see that it is a terete achene, which bears on the top a minute disc or crown, representing the calyx-limb. The seed has two plano-convex cotyledons, but no endosperm.

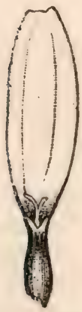

Fig. 101. Ray-floret of Ox-eye Daisy.

Inside the solitary row of ray-florets are very many (several hundred) ⚥ **disc-florets** crowded together. In these also the calyx-limb is quite absent. The corolla is not irregular as in the floret of the ray, but is **tubular** or slightly dilated in shape, and has its limb or free portion 4- or 5-toothed, showing the number of petals which are combined to form it. On the inside of the corolla-tube (which you must split open in order to find them), and attached to its walls by their filaments, you will find 5 stamens. This form of adhesion of stamens is called **epipetalous**.§ Notice that the stamens have their long slender anther-cells all joined together

* Lat. *capitulum*, a little head.
† Gr. *gamos*, union; or *sun*, together.
‡ Lat. *ligula*, a shoe-strap.
§ Gr. *epi*, upon—the petals.

into a tube which surrounds the style (= **syngenesious*** cohesion), and to the base of which the slender filaments are attached. The ovary and style are almost similar to the same parts in the ray-florets.

In speaking of Indian Cress (p. 33), what is called protandry was referred to. We find in the disc-florets of daisies and many other composites the same mode of preventing self-fertilisation of the flowers. Examine with a good lens the stamens of an (as yet) unopened disc-floret, and you will find that the anther-cells unite to form a tube (*vide supra*), into which all the pollen is discharged. At the bottom of this tube the style is found, with its two branches not yet separated. Notice that on each style-arm is a tuft of hairs. When the pollen has all been discharged into the staminal tube the style begins to elongate, and grows up through this tube, the hairs sweeping the pollen along in front of them. In florets which have just opened their corollas you will observe at the top of the staminal tube a little mass of pollen-grains which have thus been thrust out. When finally the style has elongated quite out of the tube, and has driven all the pollen before it, its two arms open outwards, and on the inner faces of these, two rows of minute papillæ may be seen, which are the stigmatic surfaces. By this contrivance it is manifestly impossible for the pistils of one of these flowers to be fertilised by its own pollen; so that, indeed, while we say the floret is ☿, it is so only in structure —in its first stage it is ♂ in function, and in its second ♀. At the same time it must be remembered that, as there are four or five hundred disc-florets crowded together, and as the outer rows open first, there is every apparent probability of the florets on one flower-head being fertilised by each other's pollen, or by that from other flower-heads on the same plant.

Fig. 102. Corolla of disc-floret of Ox-eye Daisy laid open to show attachment of stamens.

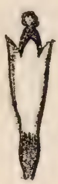

Fig. 103. Disc-floret of Ox-eye Daisy—1st stage.

Fig. 104. Disc-floret of Ox-eye Daisy—2nd stage.

(*a*.) You may take for comparison with this type a great host of other plants which differ only in greater or less detail—*e.g.*, Chamomiles (*Anthemis* and *Matricaria*), Corn Marigold and Feverfew (both belonging to *Chrysanthemum*), Yarrow or Milfoil (*Achillæa*), Common Marigold

* Gr. *sun*, together; *genesis*, birth.

(*Calendula*), Tansy* (*Tanacetum*), Wormwood* (*Artemisia*), our common New Zealand species of *Cotula*;* also Daisy (*Bellis*), *Aster*, *Celmisia*, and, indeed, all daisy-like plants. These range from trees, as in our larger *Olearias* and *Senecios*, down to moss-like herbs (*Abrotanella*), showing very retrograde development; and, while some have ligulate ray-florets, others have all the florets tubular.

(*b.*) In very many—indeed, the majority—of common composites—*e.g.*, Thistle (*Carduus*), Groundsel (*Senecio*), or *Celmisia*—the calyx-limb is developed into a persistent crown of bristles or hairs, termed a **pappus**, the function of which is manifestly to distribute the seeds by the action of wind. The form and development of this pappus differ much in different species.

Fig. 105. Disc-floret of *Celmisia* with pappus.

(*c.*) In Corn-bottle (*Centaurea cyanus*) the outer florets are not ligulate, but obliquely tubular. While among most flowers with ligulate rays we find the extra development of the corolla almost always accompanied with more or less complete abortion of the stamens, in these outer florets of *Centaurea* this abortion is complete, so that they are perfectly sterile. Their function is reduced absolutely to that of display, as by their means insects are attracted to the smaller but nectar-bearing disc-florets.

(*d.*) Examine any species of native *Raoulia* or of Everlasting Flower (wild or cultivated), and make a longitudinal section through the flower-head. Notice that all the florets have tubular corollas, the outer row usually ♀, the rest ☿, and that they are almost hidden in the long dense pappus, while the conspicuous portion of the head is formed of the hard, coloured, involucral bracts. These and the previously-cited cases furnish additional examples of a law of compensation with which you must be now tolerably familiar—namely, that when in any particular species an organ does not perform the functions which may be considered to belong to it, or performs functions usually done by some other organ, then its proper work is accomplished by some other means.

The following are additional genera to those already named in which this composite structure occurs in a more or less modified form. It is necessary to remember in examining any of these when under cultivation that the original form and structure are often greatly modified:—

Ageratum, *Coreopsis*, *Cynara* (Globe Artichoke), *Dahlia*, *Gnaphalium* (Edelweiss, &c.), *Helianthus* (Sunflower and Jerusalem Artichoke), *Tagetes* (French and African Marigolds), and *Zinnia*.

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* In these the outer florets are not very different from the inner in form, being all tubular; but the latter are ☿, the former ♀ only.

(*e*.) Examine the common Dandelion (*Taraxacum dens-leonis*). Note that the whole plant is full of white milky juice (**latex***), that all its leaves are radical and of a peculiar pinnatifid form called **runcinate**,† in which all the lobes are somewhat acute and directed a little downwards. The flower-heads are not produced in compound inflorescences (panicles, corymbs, &c.), as in so many of the other composites referred to, but each is solitary on the apex of a hollow peduncle, or **scape**‡ (a name given to any peduncle which springs directly from the top of the rootstock). Each head has a double row of involucral bracts, the outer smaller and recurved, the inner erect. The receptacle is flat, and covered with little pit-like hollows, in each of which stands a ligulate ☿ floret. All the florets are of the one type, and, though the inner ones may appear to be tubular, you will see that this is only because they have not opened. In all of them the pappus is produced like a parachute on the apex of a long stalk, which is produced from the top of the ovary. This stalk is only a prolongation of the calyx-limb. Note the spiny ridges on the achene.

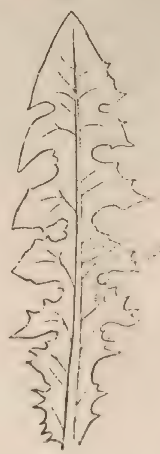

Fig. 106. Runcinate leaf of Dandelion (one-third nat. size).

Fig. 107. Fruit of Dandelion.

Compare this plant with any of the following:—

Chicory (*Cichorium*), Cat's-ear or so-called Cape-weed (*Hypochœris*), Hawk's-beard (*Crepis*), Lettuce (*Lactuca*), Nipplewort (*Lapsana*), or Sow-thistle (*Sonchus*). All of these are more or less common throughout New Zealand.

The garden Scabious, or Pincushion Flower, which is nearly allied to the composites, is worth examination. It is very like a composite, having its florets crowded into an involucrate capitulum, while its calyx-tube is produced into a kind of cup-shaped pappus bearing several bristles at its angles. But each floret has 4 *free* (not syngenesious) stamens, and the one-celled ovary bears a pendulous albuminous ovule.

14. Coprosma, sp.

A large number of species of this genus are found in New Zealand. While some are small trees with shining foliage, the majority are shrubs of various sizes (often very scrubby-

* Lat. *latex*, a liquid.
† Lat. *runcina*, a large saw.
‡ Gr. *skapos*, a stalk.

looking), with small leaves, and readily distinguished in autumn by their crimson, orange, or blue-striped berries (drupes). Karamu or Stinkwood, Mika-mik(a), Tatarahake, &c., are some of the names given to different species.

Coprosma robusta, one of the commonest species, may be taken as a type, though it matters little which one is studied. The leaves are simple, entire, and placed in opposite pairs. Instead of having a distinct pair of stipules on each petiole, those of two leaves have joined on the same side of the stem, thus forming—not four stipules to each pair of leaves, but two *interpetiolar* stipules. Note carefully the flowers, which are very inconspicuous in size and colour. They are absolutely diœcious, but you are almost certain to find two or more plants growing near one another, and showing the two kinds. On the ♂ plants the flowers have a minute 4–5-toothed calyx, a pendulous 4–5-toothed bell-shaped (=**campanulate***) corolla, which is greyish-green in colour; and 4 epipetalous stamens. These have slender filaments and **versatile**† anthers (*i.e.*, they are fastened to their filaments by a small point in the middle of their dorsal surface, and by this means they swing about very readily), and they hang a good length out of the flower. There is no trace of an ovary.

Fig. 108. Coprosma leaves with interpetiolar stipules.

Fig. 109. ♂ flowers of *Coprosma propinqua* (mag.).

Fig. 110. ♀ flower of *Coprosma propinqua*.

Next examine a ♀ plant. The flowers are even less conspicuous than in the ♂ plant, being smaller and more sparingly produced. The ovary is inferior, and has the calyx-tube adnate to it, the limb being either undeveloped or represented by 4–8 very minute teeth. The corolla is narrower than in the ♂ flowers, and is usually 4-toothed. There are

* Lat. *campanula*, a little bell.
† Lat. *versatilis*, that turns round.

no stamens, but two styles which are stigmatic (papillose) all over, and which are relatively very large as compared with the rest of the flower, in some species being as much as thirteen times as long as the corolla-tube. The fruit is a small drupe, having two stone-like cells, each containing a single erect albuminous ovule.

Fig. 111. Drupe of *Coprosma*, with upper part of mesocarp removed.

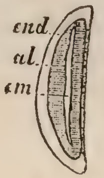

Fig. 112. Drupe of *Coprosma*; longitudinal section through the stone.
end=endocarp; *al*=endosperm; *em*=embryo.

The most interesting feature about these plants is the mode of fertilisation of their flowers. From their being so small and inconspicuously coloured, and without scent or honey, we should infer that they are not visited by insects. But, as the plants are diœcious, they must be cross-fertilised in some way, and we are impelled to the conclusion that they are anemophilous, or wind-fertilised. Their very numerous flowers, pendulous and easily-shaken anthers, light dry pollen, and relatively large styles (stigmatic all over) point irresistibly to the same conclusion.

NOTE.—The succeeding types may now be touched on more briefly than has hitherto been done, as the student should by this time have learned to observe somewhat closely, and to record observations accurately. Therefore, while exercises on all points of structure may still be required, and more detail demanded from the pupil, it is not necessary for the text-book to do more than point out salient features.

15. NATIVE HEATH, OR SNOWBERRY (*Gaultheria antipoda*).

This is an extremely variable species, ranging from a low creeping shrub, with small lanceolate serrate leaves, to a tolerably large and erect bush, with much larger broad leaves. The flowers are all solitary and axillary, but as they become crowded towards the ends of the branches, and the leaves tend to become reduced in size, they exhibit the mode in which racemes are developed. (In the closely-allied species, *G. rupestris*, the upper leaves are reduced to bracts, and then we say the inflorescence is *racemose*.)

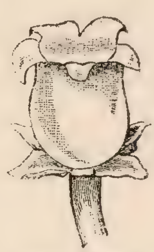

Fig. 113. Corolla of *Gaultheria* (mag.).

Note the 5-lobed inferior calyx, and the white or pink 5-toothed corolla. The latter is usually more or less contracted

at the throat (= **urceolate***—*i.e.*, pitcher- or urn-shaped), a feature characteristic of very many heaths. Carefully lay the corolla-tube open, and note the 10 hypogynous stamens. Each anther is 2-celled; these cells stand slightly apart above, and each opens by a pore or aperture at the apex, and is furnished with two dorsal appendages in the form of curved bristles called **awns**† (*i.e.*, 4 awns to each anther). The ovary is

Fig. 114. Awned stamen of *Gaultheria* (mag.).

Fig. 115. Fruit of Snowberry. *cal*=calyx.

5-celled, with several ovules in each cell, and the single style rises from the middle of a depression, and bears a small **capitate**‡ (button-like) stigma. The fruit is singular: in the commonest forms the ovary ripens into a capsule which dehisces loculicidally by 5 valves, and is enclosed in the white, red, or purplish calyx-tube, which becomes quite succulent; but in the form usually known as Snowberry the ovary itself becomes succulent or berry-like (**baccate**§) as well.

Numerous species of the Heath family (*Epacris, Dracophyllum*, &c.) occur in New Zealand, some of them being rather common.

Of these, *Cyathodes acerosa* is a tall, erect shrub, with blackish branches, and very narrow sharply-pointed (**pungent**) leaves. Its small solitary flowers are on short pedicels covered with bracts, which hide the calyx; the 5 epipetalous stamens have 1-celled anthers without awns, and the 5-celled ovary ripens into a red or white drupe, which has a bony 5-celled endocarp.

Leucopogon frazeri is a common little low-growing heath, readily recognised in spring by its fragrant flowers, and in autumn by its orange-coloured and somewhat orange-flavoured

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* Lat. *urceola*, a little pitcher.
† *Awn*, usually applied to a bristle such as occurs in barley.
‡ Lat. *caput*, a head.
§ Lat. *bacca*, a berry.

drupes. Notice that the tubular corolla has the throat bearded with dense whitish hairs, probably to prevent any insects getting at the nectar except those with long slender trunks, such as moths, certain species of which are probably the only ones able to fertilise the flowers. The ovary is 5-celled.

Compare also any species of cultivated Heaths (*Erica*), *Rhododendron*, *Azalea*, or *Arbutus*—the last remarkable for its handsome strawberry-like berry.

16. Primrose (*Primula vulgaris*).

All the leaves are radical or crowded on a very short root-stock. The flowers appear to be solitary on scapes, but on close examination it will be found that the pedicels are the branches of a nearly sessile umbel, which is furnished with a few short linear bracts. The flowers are perfectly regular, and have a tubular, 5-angled, 5-toothed inferior calyx; a 5-lobed **salver-shaped** corolla (*i.e.*, with a long narrow tube and a flat spreading limb); and 5 stamens whose filaments are connate with the corolla-tube, so that the anthers appear to be nearly sessile. The 1-celled ovary is globular, surmounted by a slender style with capitate stigma, and has numerous ovules on a free-central placenta. This ovary ripens into a capsule dehiscing by 10 teeth, of which no doubt 5 represent the dorsal sutures of the carpels, and 5 the lines of the suppressed dissepiments. The placenta is relatively very large, and the seeds are sunk in cavities on its surface. Each seed has a small straight embryo imbedded in somewhat hard endosperm.

These flowers exhibit a remarkable contrivance whereby cross-fertilisation is brought about. If a considerable number of flowers be taken from different plants it will be found that they are of two forms (=**dimorphic***) which are nearly equal in number.† In one series the style is long, so that the

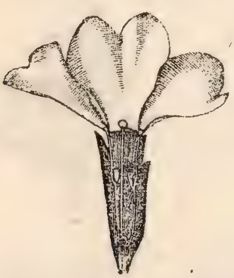

Fig. 116. Flower of Primrose—long-styled.

Fig. 117. Flower of Primrose—short-styled.

* Gr. *dis*, twice; *morphe*, form.

† As the specimens in a garden are often subdivided originally from only one or two plants, it is often the case that one or other of the forms greatly preponderates.

stigma slightly protrudes from the corolla-tube, while the anthers are found a long way down the tube. Such flowers are popularly called "pin-eyed." In the other series the anthers protrude slightly from the throat of the corolla, while the style is so short that the stigma is placed at a level corresponding with the stamens of the first-mentioned kind; and these are known as "thrum-eyed." This peculiarity is named **heterostylism,*** from the varying lengths of the styles in the two forms. It has been demonstrated by careful experiments that, in order to secure the formation of the finest capsules and the most numerous and heaviest seeds, it is necessary for the stigmas of either kind to receive pollen from the stamens of the other kind, which stand at the same level in the corolla-tube. Naturally this is what must take place, for an insect in visiting the long-styled form for nectar will get pollen on the lower part of its trunk from the stamens far down the tube: in going to a short-styled form it will probably leave some of the pollen on the stigma, and at the same time get some more pollen on the front of its head or the base of its trunk, from the stamens at the top of the tube. The latter will, in the course of the insect's visits, be transferred to the stigma of a long-styled flower. If the flowers are so protected that insects cannot get to them, it is found that they are altogether, or almost wholly, unproductive.

Any other *Primula* may be examined instead of the Primrose—*e.g.*, the Cowslip (*P. veris*), the garden Polyanthus, which is a hybrid of two or three other species, the Auricula (*P. auricula*) or *P. sinensis*. In all these the umbel is much more conspicuously developed than in *P. vulgaris*, but the flowers are almost identical in structure.

The only New Zealand plant allied to the Primrose is a creeping herb — *Samolus littoralis* — which is common in marshy ground near the sea.

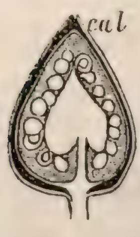

Fig. 118. *Samolus*; longitudinal section of ovary (mag.) *cal*, calyx.

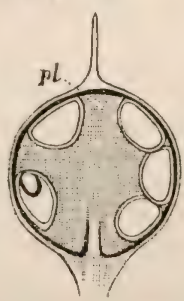

Fig. 119. Pimpernel; longitudinal section of ovary (mag.). *pl*, placenta.

Fig. 120. Capsule of Pimpernel.

Examine the common Pimpernel (*Anagallis arvensis*)—called also the Poor Man's Weather-glass, because its flowers

* Gr. *heteros*, diverse.

only open in bright weather. Note the 4-angled stems, opposite entire leaves, and solitary flowers, in which the corolla-lobes are divided nearly to the base. The fruit is a capsule, which dehisces transversely (see p. 56).

Compare with this type the Red Mapau (*Myrsine urvillei*), a common tree in many parts of the country. The flowers are very small, and crowded into little irregular clusters (**fascicles***). The calyx is 4- or 5-lobed, and the corolla formed of 4 or 5 nearly free petals, each with a stamen adnate to it. The ovary is 1-celled, and is wholly filled up by a free, thick, and somewhat fleshy placenta, in which 1, or rarely 2 or 3, ovules are imbedded. The fruit is a roundish black berry, containing one seed, as, even if more than one ovule be present in the ovary, all but one are arrested in their development. On making a longitudinal section of the seed (which has a rather hard testa), the embryo is seen lying transversely across the albumen.

17. Forget-me-not (*Myosotis palustris*).

We may take this as our next type, because it is commonly found in gardens. Some of the New Zealand species of *Myosotis* are very handsome plants, but they are not readily accessible.

Note the rough hairy character of the plant. The flowers are arranged in an inflorescence called a **scorpioid cyme.** It is theoretically a cyme in which only one lateral branch is developed at each node, giving the general appearance of a coiled-up raceme.

Fig. 121. Scorpioid cyme of Forget-me-not.

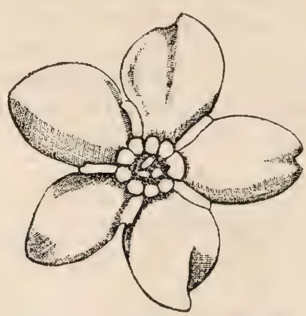

Fig. 122. Rotate corolla of Forget-me-not (mag.).

Mark the **rotate**† (wheel-shaped) corolla, with its short tube and flat spreading limb, and with the throat nearly closed by small yellowish swellings. This corolla is often liable to an alteration of colour after expanding. The pistil is

* Lat. *fasciculus*, a little bundle.
† Lat. *rota*, a wheel.

of a well-marked character. It appears to consist of four ovaries, each containing a single ovule, but on close examination is found to consist of *two* carpels, each deeply divided into two lobes. From the base of these four divisions springs the style, which is hence called **gynobasic**.* In fruit, each of the lobes of the ovary becomes a small indehiscent **nut**, with a highly-polished pericarp, which makes it look quite like a naked seed, and the whole four separate quite readily from the receptacle. The seeds have a thin testa and a nearly straight embryo, without any albumen.

Fig. 123. Fruit of Forget-me-not, in longitudinal section (mag.).

Some of our indigenous species have large flowers, with the anthers protruded (**exserted**) from the corolla-tube.

Compare the (so-called) Chatham Island Lily (*Myosotidium nobile*). This is a gigantic Forget-me-not, chiefly conspicuous by its large, ovate, perfectly glabrous leaves. As all the allies of this plant are protected by rough hairs, the want of this characteristic covering seems difficult to account for until we remember that the species is now found only in the Chatham Islands, where presumably there are few or no insects of a kind which would prey on its succulent leaves and stems. Probably it was at one time common throughout New Zealand, but became extinct in all parts except these outlying islands. The fruit is rather different from that of *Myosotis*, the receptacle being produced upwards between the lobes of the ovary into a fleshy column, and the 4 nuts being compressed and winged.

The following plants, all of which possess gamopetalous corollas, will be found suitable for examination and class-exercises in connection with the preceding types:—

Jasmine (*Jasminum*), Privet (*Ligustrum*), Ash (*Fraxinus*), and Lilac (*Syringa*)† have 2 stamens and a 2-celled ovary.

Parsonsia albiflora and *P. rosea* are common indigenous climbers, with very variable simple leaves, and panicles of white or pinkish flowers. The 5 anthers cohere in a remarkable manner; in each, one cell containing pollen opens inwards against the style, while the other is empty and opens out-

* *Lit.* from the base of the gynœcium.

† This name is often popularly given to the Mock Orange (*Philadelphus coronaria*), a plant quite distinct, and very different from the Lilac.

wards. The stigma is furnished below with a disc, round which the anther-cells are fastened. The 2-celled ovary divides, when ripe, into two long slender follicles, thus liberating a number of seeds, each furnished with a tuft of hairs at the hilum.

Fig. 124. Stamens of *Parsonsia* (mag.).

Fig. 125. Seed of *Parsonsia*.

Compare here also Periwinkle (*Vinca*), and note its remarkable stigma, shaped like an hour-glass.

Of Gentians (*Gentiana*), the garden species are all European, and are blue-coloured. The New Zealand species are white, and some are very handsome; they flower in February and March.

Nemophila, *Phlox*, *Gilia*, *Cobœa*, &c., are commonly cultivated in gardens.

Of *Convolvulus* and *Ipomœa*, both wild and cultivated species are common.

Poroporo, or, as it is commonly pronounced, Bullibulli (*Solanum aviculare*), Potato (*S. tuberosum*), *Petunia*, Tobacco (*Nicotiana*), Tomato (*Lycopersicum*), &c., all with regular flowers, a 2-celled ovary, and seeds having a curved embryo in fleshy albumen, are more or less common.

18. Frogsmouth, or Snapdragon (*Antirrhinum majus*).

The flowers are extremely irregular, and are arranged in bracteate racemes. The 5-lobed inferior calyx is imbricate and persistent. The hypogynous corolla is also 5-lobed, and distinctly **bilabiate**,* or two-lipped. The upper lip is 2- and the lower 3-lobed, the opposite arrangement prevailing in the calyx. The lips are closely pressed together, and this form of bilabiate corolla is called **personate**.† The object of such a structure is evidently to prevent any but suitable insects from entering the flower; and it appears to depend for its fertilisation solely upon different species of bees, which alone among flower-loving insects are strong enough to force

* Lat. *bis*, twice; *labium*, a lip.
† Lat. *persona*, a mask.

the lips apart. That this is so has been proved by the fact that after the stigma has been covered with pollen the elas-

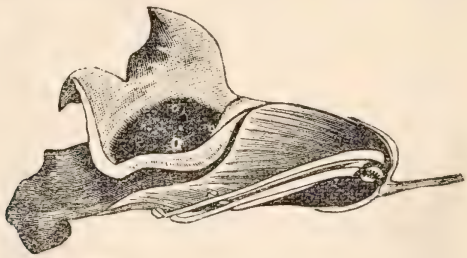

Fig. 126. Flower of *Antirrhinum;* longitudinal section.

ticity of the corolla diminishes, so that ants and other insects can get in and carry off the nectar. The four stamens stand close against the upper lip in such a position that a bee, forcing its way into the flower, is certain to brush the head and back against them. Two have long and two short filaments, and this form of cohesion is called **didynamous.*** The anther-cells diverge somewhat widely. The 2-celled ovary is furnished with a simple style, ending in an imperfectly-2-lobed stigma, which projects between the upper

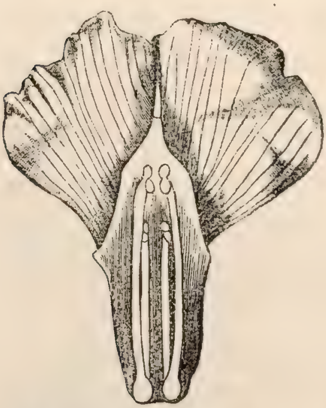

Fig. 127. Upper lip of corolla of *Antirrhinum*, with didynamous stamens.

Fig. 128. Capsule of *Antirrhinum* (immature).

Fig. 129. Capsule of *Antirrhinum*, dehiscing by pores.

and lower anthers. The fruit is a capsule, of which the upper cell opens by one large pore and the lower by two small ones. The small seeds have a ridged and prickly testa, and a straight embryo in fleshy endosperm.

Compare with this type one or other of our numerous species of *Veronica*, one of the most characteristic of New Zealand genera. With a very few exceptions all these plants are shrubs, and many of them so imitate other plants in their

* Gr. *dis*, twice; *dunamis*, power.

general appearance that botanists have given them significant names—*e.g.*, *V. salicifolia* (willow-leaved), *V. ligustrifolia* (privet-leaved), *V. buxifolia* (box-leaved), commonly called New Zealand box, *V. lycopodioides* (like club-moss), *V. cupressoides* (like cypress), and many others. In these the leaves are all opposite, and in some cases (*e.g.*, *V. tetrasticha*) so closely packed as to make the branches with their leaves appear like pieces of carved wood. The flowers are most commonly arranged in more or less dense racemes. The calyx is 4-partite, its divisions being separated nearly to the base. The open corolla is somewhat unequally 4-lobed, and is only imperfectly 2-lipped. Only 2 stamens are present, no more ever being developed. The 2-celled ovary ripens into a capsule, which differs a good deal in shape in the different species, but usually dehisces septicidally.

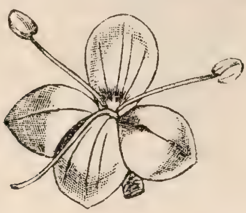

Fig. 130. Corolla of *Veronica carnosula* (mag.).

Fig. 131. Dehiscing capsule of *Veronica traversii* (mag.).

A great number of familiar plants belong to this type, in which, with considerable variation of detail, the general features are very persistent. The following are among the commonest:—

Calceolaria, of which one New Zealand species—*C. sinclairii*—is to be found in cultivation—remarkable for its inflated corolla-lips. Only 2 stamens are present.

Pentstemon, remarkable for the occurrence of a fifth modified stamen, which, however, has no anther-lobes. Presumably the ancestral forms from which all the plants of this type are descended were furnished with five stamens; in most cases *one*, but in others *three*, of these have ceased to be developed.

Mimulus.—Two indigenous species, *M. radicans* and *M. repens*, are to be found. In gardens, Musk (*M. moschatus*) and various hybrids of *M. luteus*, &c., are common. All are characterized by having a stigma composed of two plates or lamellæ, the lower of which is irritable. If it be rubbed with a clean feather or brush it closes up, but reopens again after an interval of less than an hour. But if a little pollen from another flower be brushed on to it it closes up and does not reopen. It is easy to see that only an insect entering the flower with pollen on its head can leave this on the lower stigmatic lobe; one withdrawing its head will only brush the under-side, not the stigmatic side, of the lobe. In this way fertilisation can only be brought about by pollen from another flower.

Fig. 132. Style and open stigma of *Mimulus radicans*.

Fig. 133. Same, closed.

Compare also any of the following genera: *Salpiglossis*, *Schizanthus* (so named from its split corolla), *Alonsoa*, *Linaria*, *Digitalis* (Foxglove), *Ourisia*, *Euphrasia* (Eyebright), introduced species of *Veronica*, &c.

19. Spear-mint (*Mentha viridis*).

This common garden herb has run wild in many parts of the colony, particularly in damp places and along the banks of streams. Note the powerful aromatic smell, the square stems, and opposite leaves. Towards the ends of the branches the flowers appear crowded into terminal spikes. A close examination of the inflorescence shows that the upper leaves become greatly reduced in size, while in their axils small flattened cymes of flowers are produced, and these in consequence appear to be whorled. The calyx is acutely 5-toothed, and persistent. Under a strong lens its surface appears to be covered with small oil-glands. Similar glands, but not so conspicuous, are scattered over the whole plant, and to these the aroma is due. The corolla is 4-lobed, but a notch in the upper lobe shows that it is composed of two united together. Thus a 2-lipped structure is distinguishable, though it is somewhat masked by the relatively small size and undivided appearance of the upper lip. The 4 stamens are about equal in length, while the ovary is remarkably similar in its general structure to that of Forget-me-not (p. 68), being 2-celled, with each cell deeply 2-lobed, and containing a single inverted ovule. The fruit also is so deeply 4-lobed as to appear as 4 minute smooth nutlets.

The plant is not a good type of the group to which it belongs, and which are called *Labiates* on account of the usually strongly-marked 1- or 2-lipped corolla, but we have described it in order to compare it with our only common New Zealand labiate, which is also a Mint—viz., *M. cunninghamii*. This little plant is common in dry hilly ground all over the country, and produces its solitary and axillary white flowers from December to February. These flowers are protandrous, and only differ in small details of structure from the introduced species.

Fig. 134. Flowers of N.Z. Mint, × 3.

Fig. 135. N.Z. Mint Pistil, × 4.

A much better example of this type of plants is the introduced Self-heal (*Prunella vulgaris*), an extremely common weed in grassy land throughout these islands. The floral clusters are subtended by large rounded bracts. The calyx is distinctly 2-lipped, the upper lip being flattened and 3-toothed, and the lower 2-toothed. The purple corolla is also 2-lipped, but the order is the reverse of that which prevails in the calyx. The 4 stamens are didynamous, the anthers meeting in pairs, and having their cells diverging widely from one another.

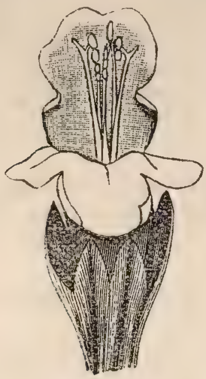

Fig. 136. Flower of *Prunella*, from the front (mag.).

Fig. 137. Stamen of *Prunella* (mag.).

Compare also with these Thyme (*Thymus*), Marjoram (*Origanum*), Balm (*Melissa*), Horehound (*Marrubium*), or Lavender (*Lavandula*).

In Sage (*Salvia officinalis*) only two stamens are developed, and these have the connective produced into an elongated curved arm, with an anther at each end, that at the upper end being fully developed, while the other is abortive. This is a contrivance to insure the dusting of the pollen on to the back of any insect entering the flower. If you look into a Salvia flower, you see the two pollen-bearing anthers standing up against the upper lip of the corolla: now thrust the blunt end of a pencil into the flower, and notice that as soon as the lower ends of the connectives are forced down the upper ends come forward and touch the pencil. Of course, if it were a bee instead of a pencil you can see that it would receive a dusting of pollen on its back. This peculiarity of structure is even better seen in the handsome red and blue Salvias (*S. fulgens* and *S. patens*) of the flower-border.

Fig. 138. Flower of Sage.

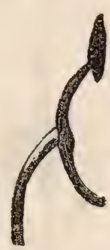

Fig. 139. Stamen of Sage (mag.).

Lastly, in Rosemary (*Rosmarinus*) the same form of structure occurs, but the lower anther-cell is not developed at all.

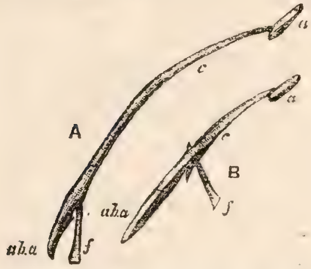

Fig. 140. Stamens of (A) *Salvia patens* and (B) *Salvia fulgens*. *a*, fertile anther; *c*, connective; *ab.a*, abortive anther; *f*, filament.

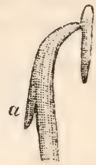

Fig. 141. Stamen of Rosemary (mag.). *a*, abortive anther.

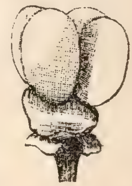

Fig. 142. Fruit of Sage (mag.).

The fruit of the Sage resembles in general character that of Forget-me-not (see p. 68).

20. Plantain, or Ribgrass (*Plantago major* and *P. lanceolata*).

Both species are now very common in New Zealand, having been introduced here from Britain. *P. major* has ovate-oblong leaves 3–6in. long, a short scape, and a very long flower-spike, from which the plant has received the common name of rat's-tail; the seeds are used for feeding cage-birds. *P. lanceolata* has lanceolate leaves 6–12in. long, and a long scape bearing a short spike of flowers. Whichever species is examined, notice that the leaves are all radical and have from 3 to 7 nearly parallel ribs, while the flowers are arranged in terminal **spikes** (a spike differing from a raceme only in the flowers being sessile on the rachis instead of being pedicelled). The individual flowers are greenish in colour and are composed of 4 persistent imbricate sepals, a 4-lobed salver-shaped scarious corolla, 4 stamens having long very slender filaments and large versatile anthers, and a 2-celled ovary. The latter is crowned with a single **filiform**[*] (thread-like) style, which, however, has two rows of stigmatic papillæ, one on each side. In both species the fruit is a capsule dehiscing transversely, containing 2 (in *P. lanceolata*) or several seeds (in *P. major*).

Fig. 143. Flower of *Plantago lanceolata*, 1st stage.

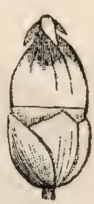

Fig. 144. Capsule of *Plantago*, dehiscing transversely.

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* Lat. *filum*, a thread.

All plants having gamopetalous corollas are considered by botanists to constitute the most highly-developed section of flowering-plants—that is to say, they form the most highly-specialised group; but frequently even amongst these we meet with retrogression. Such, undoubtedly, are *Abrotanella*, most species of *Cotula*, &c., among Composites (p. 60), and probably also such plants as *Coprosma*, *Myrsine*, &c. We meet with the same fact of retrograde development in the small family of plants represented by *Plantago*. The flowers have become anemophilous (wind-fertilised), and have quite lost any brilliance of colour the corolla may have ever possessed. At the same time they have retained the advantages to be derived from cross-fertilisation by having their flowers protogynous, the flowers at the bottom of the spike protruding their styles first, and these withering away before the anthers hang out. Thus, on the same spike the styles of the upper flowers are usually protruded at the same time as the anthers of the lower.

Fig. 145. Flower of *Plantago lanceolata*, 2nd stage.

FLORAL DIAGRAMS.

An excellent and graphic mode of illustrating many details of the structure of a flower is to draw what is called a *floral diagram*. This is really a sort of ground-plan of the flower as looked at from above, the parts being represented as if they lay on one plane.

When we make a longitudinal section through a flower we obtain a very good idea of the relative position of the floral whorls with regard to one another—*i.e.*, of the adhesion of the different whorls; but a drawing of such a section does not necessarily give much information as to their cohesion, æstivation, &c. This can only be graphically represented by the floral diagram. Theoretically, the diagram represents the appearance of a section taken transversely through a flower-bud; but, as sections taken at different heights give different appearances, it is necessary to combine these in the figure.

In drawing these diagrams the pupil should either be furnished with coloured pencils or, better still, should adopt a certain rule for representing the floral whorls with the ordinary pencil. Thus the sepals may always be represented—as shown in the diagrams given in this work—by double lines transversely shaded; the petals by double lines filled in with dark shading; the stamens by figures resembling the anther in transverse section; while the appearance of the ovary in transverse section may be faithfully reproduced.

Let us take as the first example of our diagram that of a single Pink or Sweet William. In commencing, let the pupil draw very faintly *four* concentric circles, the largest about 2in. in diameter, within which to construct his plan. Now, if a transverse section be made through the lower part of a flower-bud (after removing the bracts) the calyx will appear as a single ring, while if it be made near the top it would only appear as five very short lines. By combining these appearances we represent the calyx, on the outer circle of the diagram, by 5 curved lines (*ca*), whose ends are united to show that the cohesion is gamosepalous. If we examine a very young bud we find that two of the sepals (1 and 2) are external to the others, a third (3) overlaps one of its neighbours by an edge, while the two inner (4 and 5) are themselves overlapped on both edges: the imbricate nature of the æstivation may thus be accurately represented. On the second circle the petals

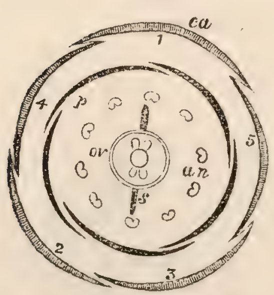

Fig. 146. Floral diagram of Pink (*Dianthus*).

are to be drawn (*p*): these are all separate, and each one overlaps its neighbour on one side, and is itself overlapped on the other. The ten stamens appear all in *one* whorl (*an*), all separate from one another and from the other whorls, and are therefore placed on the third circle. Note that 5 of them are alternate with and 5 opposite the petals. The ovary (*ov*), with its free-central placenta in the centre, will occupy the fourth circle. In the latter a little care in its examination will reveal the fact that the ovules are in two series on the placental column, which, indeed, opens into two in its upper part, and is continuous with the two arms of the style. These latter may be represented as small lateral projections of the ovary (*s*, *s*), their relative position to the other parts being carefully marked.

The flower of Dianthus is quite regular. It will therefore be advisable to see how the diagram of the Pansy or Violet flower, which is irregular, is to be constructed. Here, again, 4 circles are first to be traced. Of the 5 free imbricate sepals, two are external, two more are each overlapped on one edge, while the fifth is internal, and is overlapped on each edge;* but the projection of one of the petals prevents this being clearly made out. The 5 petals are also free and imbricate, but the lower or anterior one (*i.e.*, the one furthest from the axis of the inflorescence) has a spur produced backwards between the two lower sepals. The 5 stamens have broadly-dilated connectives, which may be represented by curved dorsal lines, while also the appendages of the two lower can be shown projecting into the spur of the anterior petal. The 1-celled ovary has three parietal placentæ, whose position with regard to the axis of the flower must be accurately noted; but the style, being simple, cannot be shown.

Fig. 147. Floral Diagram of Pansy.

As a somewhat different type, let us next take a Fuchsia. In this the 4 sepals are united and valvate, and this feature can be represented by drawing a continuous circle, the thickened portions of which end in

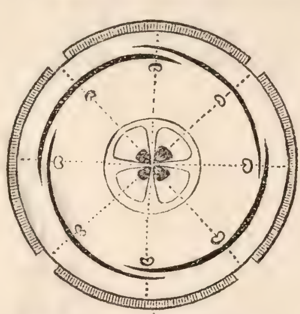

Fig. 148. Floral diagram of Fuchsia.

* The æstivation of the calyx has not been quite correctly reproduced in the accompanying figure.

abrupt margins. The petals are contorted in all the hybridized garden species.

It is important to notice that, as a rule, petals are alternate with sepals, their margins being opposite the middles of the calyx-lobes, as is the case here. This feature, and similarly the position of the stamens with regard to the petals, can be accurately shown by the floral diagram, and must be carefully noted. The correct position of these floral whorls is most accurately fixed by drawing faint radii through the sepals, and subdividing the space between these by other radii, as shown by the dotted lines in the figure.

It is not advisable to attempt to show the adhesion of the whorls in the diagram, unless this can be done without sacrificing the clearness of the figure. Thus, when the petals are inserted on the calyx (perigynous) this may be represented by thin lines uniting the two like radii; but the adhesion of stamens to sepals, which is a common feature, cannot be shown by the same method. Again, epipetalous stamens can generally be shown by a similar line, but no other feature of the adhesion should be attempted. It is, perhaps, questionable whether any great advantage is derivable from the construction of such *empirical* diagrams, and whether the object sought to be attained would not be better secured by actual drawings of transverse and longitudinal sections.

But the floral diagram is frequently used to indicate not only the parts of the flower which are present, but those also which are wanting—*i.e.*, those parts which have been suppressed during development. Such *theoretical* diagrams can, of course, only be constructed when the development of the plant and of its allies is known, and they then become extremely valuable as a concise method of showing and clearly explaining the mode in which the structure of the flower has been attained. In these diagrams the number and position only of the floral whorls are represented, without reference to their cohesion, adhesion, or æstivation; the position of those

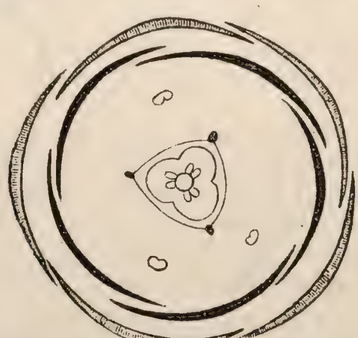

Fig. 149. Floral diagram of Chickweed—empirical.

whorls or parts of whorls which have been suppressed is shown by a dot, and of those which have been aborted or produced imperfectly by a shaded dot. For example, the ordinary chickweed has only 3 stamens, though derived from a typical 10-stamened flower. The empirical and theoretical diagrams of the flower are shown in the accompanying figures, the first showing the cohesion and æstivation of the parts as they actually exist, the second serving to show what parts of the flower have been suppressed in development. (For other examples of the theoretical diagram, see p. 97 and p. 103.)

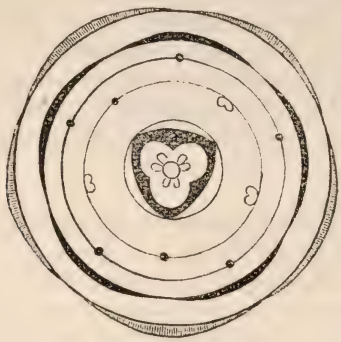

Fig. 150. Floral diagram of Chickweed—theoretical.

CHAPTER V.

HITHERTO the flowers which have been examined and described have possessed (with a few exceptions) a double perianth, readily distinguishable into calyx and corolla. Those to be described in this chapter are usually furnished with a single perianth, or are destitute of any floral envelope. In those cases where the perianth is double it is not distinguishable into calyx and corolla, all the leaves, as a rule, being of similar structure.

21. DOCK (*Rumex obtusifolius* and *R. crispus*).

Two or three kinds of Dock are common in New Zealand, but probably the two named are the most abundant. There are also two native species, one of them—*R. flexuosus*—which has tough much-branched prostrate stems and narrow leaves, being very common.

In all docks the leaves are **revolute*** in **vernation**†—that is to say, their margins are rolled outwards before they expand (the term *vernation* being applied to the mode of folding of leaves in the bud). The leaves are furnished with very characteristic stipules called **ochreæ,**‡ which, instead of being placed at the sides of the petiole like wings, form a sort of sheath to the stem above the attachment of the petiole. These ochreæ are usually of very thin scarious texture.

The small green flowers are crowded into panicles which are arranged in whorls in the upper portions of the branches. Each flower has a perianth of 6 leaves arranged in two whorls, the inner three of which in *R. obtusifolius* have strongly-toothed margins, while in *R. crispus* they are nearly entire. They are generally furnished on the midrib with a swollen knob or tubercle. There are 6 stamens, and a 1-celled, sharply-3-angled (**triquetrous**§) ovary. From the apex of the latter, and projecting over each of its angles, is a slender style, bearing a flattened and feathery stigma. In longitudinal section the ovary is found to contain a single erect ovule.

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* Lat. *re*, back; *volvo*, I roll.
† Lat. *ver*, spring, hence *vernatio*.
‡ Lat. *ocrea*, a covering to protect the legs.
§ Lat. *triquetrus*, three-sided.

As the ovary ripens to fruit the three inner perianth-leaves enlarge very considerably, and close over it. The fruit is a 3-angled nut containing 1 seed, which has a slightly-curved embryo in the midst of a mass of mealy endosperm.

Fig. 151. Fruit of the Dock enclosed in the persistent perianth (mag.).

Fig. 152. Fruit of the Dock removed from its perianth (mag.).

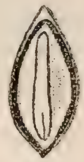

Fig. 153. Fruit of the Dock, longitudinal section (mag.).

Compare with this the common (Sheep's) Sorrel (*Rumex acetosella*), which is such a pest in cultivated land. Note the hastate (spear-shaped) leaves (see Pl. III., fig. 9) and the diœcious flowers, which in structure are very similar to those of the Dock.

Closely allied to this type also are Rhubarb (*Rheum*) and Buckwheat (*Fagopyrum*), the former universally and the latter occasionally cultivated in this colony.

Muhlenbeckia adpressa, a common climbing plant at the edges of the bush, is another near ally. Its flowers are commonly diœcious, and are clustered in short spikes arranged in panicles. The peculiarity of the plant consists in its 5-lobed perianth not only remaining persistent, but becoming succulent in fruit, recalling in this respect the structure of the fruit (pseudocarp) of tutu. The black nut is usually 3-winged, but contains only a single erect seed.

Fig. 154. Fruit of *Muhlenbeckia* enclosed in the fleshy perianth (mag.).

Fig. 155. Fruit of *Muhlenbeckia* after removal of the perianth, longitudinal section (mag.).

The following plants should, if possible, be examined, but owing to the small size of the flowers their structure cannot be well made out unless with the aid of a dissecting microscope of fairly high power: Beetroot (*Beta*), Goosefoot or Fat Hen (*Chenopodium*), and Spinach (*Spinacia*). Compare the seeds with those of Chickweed (p. 24): all agree in possessing a curved embryo surrounding mealy endosperm. Closely allied to these is *Salicornia indica*, a common plant on mud-flats near the sea, having fleshy, jointed, leafless stems, and flowers much reduced in structure.

The genus *Pimelea* is common in many parts of the colony. The plants are frequently mistaken for Veronicas, owing to

their shrubby habit and opposite entire leaves. The flowers have a white corolla-like 4-lobed perianth, with 2 **epiphyllous*** stamens—*i.e.*, inserted on the perianth-leaves. The 1-celled ovary contains a single ovule, and has a lateral style. The fruit is a nut, but in some species the persistent perianth becomes succulent and berry-like. (Compare *Gaultheria*, p. 64.) In some species there appears to be a tendency to heterostylism in the flowers: look for this character.

22. Willow (*Salix* sp.).

So many species of Willow are now to be found in the colony that it is not easy to select any one suitable for a type as the commonest. Perhaps the most distinctive is the Sallow, or Goat Willow (*S. caprea*). In this, as in some other species, the diœcious flowers come out before the leaves, and the ♂ are very different-looking from the ♀. All are arranged in dense spikes called **catkins**, each flower being in the axil of,

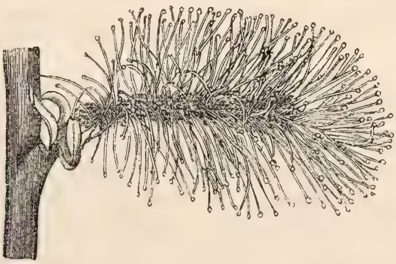

Fig. 156. ♂ catkin of Goat Willow.

Fig. 157. ♂ flower of Goat Willow (mag.).

and nearly covered by, a silky membranous bract. The ♂ catkins are about 1in. long, and each flower consists of 2 (seldom more) stamens placed under a small glandular disc which represents the perianth. The whole inflorescence drops off after the pollen has been scattered. The ♀ catkins are considerably longer, and increase in length as the fruit matures. Each flower consists of a single gland, as in the ♂, and a 1-celled ovary, ending above in a very short style, with 2-lobed stigma, the whole placed on a short pedicel. In transverse section the ovary is seen to contain numerous ovules on two parietal placentæ. The ovary ripens into a capsule which dehisces loculicidally, the 2 valves rolling backwards. The minute seeds are furnished with and enveloped by a tuft of hairs springing from the short thick

Fig. 158. ♀ flower of Goat Willow (mag.).

* Gr. *epi*, upon; *phyllon*, a leaf.

funicle, and which apparently serves as a means of distributing them by means of the wind. (Compare *Parsonsia*, p. 69.)

Fig. 159. Dehiscing capsule of Goat Willow (mag.).

Fig. 160. Seed of Goat Willow (mag.).

Nearly allied to the Willows are the Poplars (*Populus*), of which a number of species have been introduced. In most of them the catkins are pendulous, and the bracts are very much divided. The stamens also are very numerous in many species, and the disc is cup-shaped with an oblique margin ; in some ♀ flowers the stigma is 2-lobed, and in others 4-lobed.

The so-called New Zealand Birches have received the name from their general resemblance—particularly in the size of their leaves—to the European Birch. They are, however, true Beeches, and belong to the genus *Fagus*. There are four species known here ; they are particularly common in (though not confined to) the western half of the South Island and the mountainous parts of the North Island. The flowers are monœcious, and the catkins, which are so characteristic of all plants of this type, are in them reduced to one, two, or at the most four flowers. Each ♂ flower has a cup-like perianth

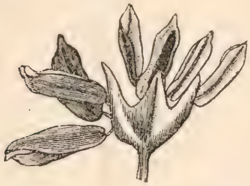

Fig. 161. ♂ flower of *Fagus menziesii* (mag.).

Fig. 162. Fruiting involucre of *Fagus menziesii* (mag.).

with 5 or 6 lobes, enclosing from 8 to 12 free stamens. Each ♀ flower consists of an ovary enclosed in an urceolate perianth, which is usually more or less distinctly 6-lobed, and two or three of these are enclosed in an outer involucre consisting of 4 bracts. Each ovary is 3-celled, and furnished above with 3 linear styles, while 1 (or 2) pendulous ovules are present in

each cell. During ripening the outer involucre becomes hard and woody, and the ovaries mature into 3-angled winged nuts, in which only 1 seed is found, the other (if originally present) having its development arrested. The seed is exalbuminous, and has thick fleshy folded cotyledons enclosed in a thin testa; but this feature is not readily visible until the seed is very ripe.

Fig. 163. Involucre of *Fagus* after the nuts have fallen (mag.).

Fig. 164. 3-cornered nut of *Fagus* (mag).

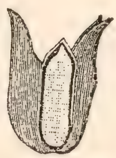

Fig. 165. Nut of *Fagus*, long. section (mag.).

Fig. 166. Nut of *Fagus*, trans. section (mag.).

The Oak and Hazel may be compared with the preceding. The development of the acorn furnishes a good example of the process of arrest, as out of the 6 ovules originally present in each ovary only *one* comes to maturity.

23. Euphorbia glauca.

This Spurge is common along the sea-coasts of these Islands, and perhaps is most familiarly known from the burning milky juice (latex) with which it abounds. Where this particular species cannot be readily obtained, one of the common introduced species, *E. helioscopia*, *E. peplus* (a very abundant weed in many gardens), or the large *E. lathyris*, may be studied. The general structure of all these will be found to be the same.

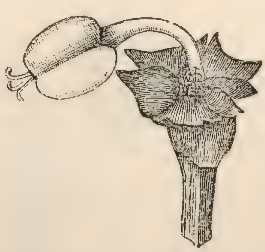

Fig. 167. Inflorescence of *Euphorbia glauca* (mag.).

Fig. 168. Staminate flower of *Euphorbia glauca* jointed on to its pedicel (mag.).

The flowers are monœcious, one ♀ and several ♂ flowers being collected into an inflorescence, which is popularly termed the flower. This inflorescence is surrounded by a

perianth-like involucre of 4 or 5 united bracts, each expanded on its upper margin into a flat purple *lunate* (crescent-shaped) gland.* Within this pseudo-perianth is found a varying number of ♂ flowers, each consisting of a pedicel of varying length, bearing a single stamen, which has a 2-celled anther. In the centre of the inflorescence is one pedicelled ♀ flower, consisting of a 3-celled ovary with a single pendulous ovule in each cell, and bearing a 3-fid style. This ovary ripens into a 3-lobed capsule, which, from the elongation of its pedicel, hangs out of the involucre. When mature, the capsule splits (like a schizocarp) into its three original carpels, and each further opens by a dorsal valve. The seeds are albuminous, and the straight embryo has a narrow radicle with flat cotyledons.

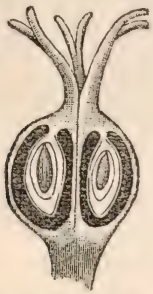

Fig. 169. Ovary of *Euphorbia*, longitudinal section (mag.).

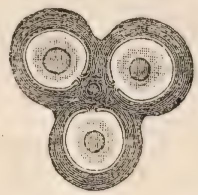

Fig. 170. Ovary of *Euphorbia*, transverse section (mag.).

* The term *gland* is applied in the animal kingdom to an organ of secretion, and in this strict sense is also used in vegetable anatomy. But it is also employed in a less exact manner to designate any wart-like external swelling in plants (whether its function is known or not) as well as to oil-cavities and other excreting organs.

STRUCTURE OF ROOTS AND UNDERGROUND STEMS.

These parts of plants may be conveniently studied in the field or garden, but it will be found practically difficult in many cases to introduce them into the class-room unless they have been previously cleaned for examination. Frequently also their structure and mode of growth can only be accurately made out *in situ*.

The **root** is the part which serves to attach the plant to the ground, and to absorb from the soil the liquid nutriment requisite for its growth. Its direction of growth is quite different from that of the rest of the plant, as it always seeks to go downwards and to avoid the light. And this difference is manifested from the beginning of the plant's life. If we soak a bean in water, and then lay it on the surface of damp soil in a flower-pot, the first thing to protrude from the testa will be the radicle, and this will immediately proceed to bury itself in the soil; and this attempt will continue, in whatever direction we turn it.

A root formed in this way, by the direct elongation of the radicle, is called a **tap-root**, and, necessarily, in all the plants we have hitherto considered, the first root is always a tap-root. In a large number of plants—*e.g.*, in most trees—this kind of root is persistent, and often attains a great size. A true root is never green-coloured, nor does it produce leaf-buds, however many branches or secondary roots may be developed. When these secondary roots are produced in great abundance the root is **fibrous.** If it consists of a few tufted thickened fibres it is termed **fasciculated,** and when the thickening causes the main portion of the fibres to be greatly swollen they are said to be **tuberous,** as in the Dahlia. In all such cases of thickening, in addition to the usual root-function, there has been acquired the secondary function of storing up food-materials, such as starch, sugar, oil, &c. This tendency in many plants has been taken advan-

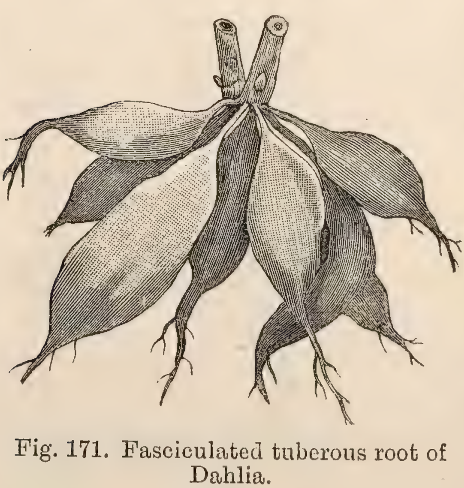

Fig. 171. Fasciculated tuberous root of Dahlia.

tage of by the agriculturist and gardener, and by their labours in developing what is already a natural tendency of these plants we have acquired many varieties of turnips, carrots, parsnips, beetroot, and radish, which serve as food for man and beast. Were these plants to be left to grow for a second year, they would use up, in the production of their seed, all the material stored during their first year.

It has been already said that in all the plants hitherto considered the first root is a tap-root, developing directly from the elongation of the radicle of the embryo. But, besides these, roots may arise in other ways, and all such are included in the general term **adventitious** roots. For example, when we put a cutting, say of a geranium, into the ground, it usually puts out such adventitious roots, and develops into a new plant. Many plants do this naturally (*e.g.*, strawberry), and it is one of their normal means of reproduction. And, further, in the tropics and in humid regions aerial roots are common. These either remain permanently above the ground, as in epiphytes (see p. 94), or are sent down from the branches to the soil or mud below, as in the Banyan tree of India. Lastly, a few plants develop special forms of adventitious roots for the purpose of support, as in the Ivy; but these do not serve at all to nourish the plant.

Underground stems are readily distinguished from roots by their producing buds, from which leaves and leaf-bearing branches are sent up. They may be classed under three heads—viz., **rhizomes**, **tubers**, and **bulbs**—but popularly all are known as roots.

The **rhizome**,* or **root-stock**, is always elongated, and sends roots down from its lower, and leaves and branches up from its upper surface. Rhizomes are various in form and appearance. Usually they are somewhat thickened, and creep along either at or just below the surface of the soil. Fre-

Fig. 172. Rhizome of Iris.

* Gr. *rhiza*, a root, from their resemblance to roots.

quently they are very much thickened, and serve as stores of nutritive material for the plant, just as some roots do. Ginger is the dried rhizome of a tropical plant, and furnishes a good example. In some plants the rhizomes are greatly elongated, and creep for a great length in the soil, as is the

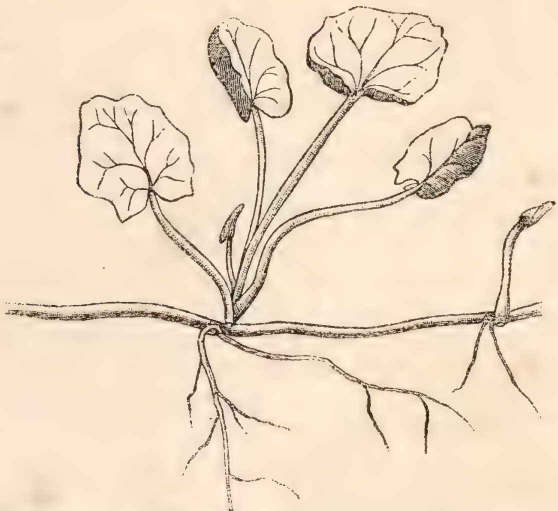

Fig. 173. *Hydrocotyle asiatica*, showing the creeping rhizomes.

case in many sea-side and swamp plants—*e.g.*, *Mimulus repens*, *Convolvulus soldanella*, &c. Plants having such rhizomes are often of great service for binding loose sand, but in cultivation they frequently become dreadful pests. Three of the worst weeds we have in New Zealand—viz., Sorrel (*Rumex acetosella*), one of the Couch-grasses (*Poa pratensis*), and the Creeping Thistle* (*Carduus arvensis*)—spread by means of their long slender rhizomes. Hence the difficulty of eradicating these plants, as every little bit of stem bearing a bud is capable of reproducing a new plant.

The **tuber**† is a short, more or less rounded, and thickened stem, bearing buds on its surface. The most familiar example is found in the potato. It serves chiefly as a mode of reproduction, there being always a quantity of nutritive material (most commonly starch) stored up in it for the new plant.

The **bulb**‡ is a short thick stem, consisting of a central

* This plant is popularly but incorrectly known as the Californian or Canadian thistle. It is common enough in Canada, and perhaps in California, but was introduced into America from Europe, where it is indigenous, and from whence it was brought to this colony.

† Lat. *tuber*, a lump or excrescence.

‡ Lat. *bulbus*, a globular root, an onion.

bud surrounded by more or less thickened scale-leaves. It serves the same purpose as the tuber, being chiefly a means of reproduction, but its reserve of nutriment is stored up chiefly in its scales. The Onion, Lily, &c., are familiar examples of bulbs. The transition stage between the bulb and the rhizome is seen in such solid bulbs (or **corms***) as occur in Crocus and Gladiolus. In some plants—*e.g.*, the Tiger Lily—the upper axillary buds or branches are normally developed as small bulbs, or bulbils, which drop off the parent plant in autumn, and germinate at once if the soil be damp.

* Gr. *kormos*, a log or trunk.

CHAPTER VI.

24. Iris, Flag-lily, or Fleur-de-lys (*Iris germanica*).

With this type we enter on the examination of a series of plants differing in a very considerable degree from all previously described. This plant is not only commonly cultivated in gardens, but has run wild in many parts of New Zealand, particularly in the North Island.

Note the thick prostrate rhizome sending up its tufts of leaves (see fig. 172). These are sessile and alternate, their bases sheathing one another in two parallel ranks: this arrangement is called **equitant.*** Each leaf is **ensiform,**† or sword-shaped, and the two sides of the blade are longitudinally folded together. Note the *parallel* venation and the entire margins.

The flowers are produced on scapes, and each is covered in bud by 2 **spathes**‡ (this name being applied to any large covering bracts which completely envelop a flower or inflorescence). Each flower has a superior 6-leaved petaloid perianth, of which the outer 3 leaves represent sepals, and the inner 3 petals. On the base of the three outer segments the 3 stamens are inserted, each filament bearing a long narrow 2-celled basifixed anther, which opens outwardly (*extrorse*), or away from the stigmas. The ovary is inferior and 3-celled, having numerous ovules on 3 axile placentæ. The 3 stigmas, which are opposite to the stamens, are expanded into bifid petaloid lobes having their stigmatic surface on the under-side of the lamella. The fruit is a 3-celled capsule, which dehisces loculicidally, and the numerous seeds have a short terete embryo in the centre of somewhat firm, almost horny, endosperm.

The most notable differences between this plant and all which we have previously considered are, the absolutely parallel venation of its leaves, and the uniformly trimerous (in 3s) symmetry of its flowers. These characteristics will be found to prevail in most of the succeeding types.

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* Lat. *equitans*, riding.

† Lat. *ensis*, a sword.

‡ Gr. *spăthē*, a flat piece of wood.

Numerous other species of *Iris* are to be found in gardens; these have all the same floral structure as *I. germanica*. Compare also with them the small native iridaceous plants belonging to the genus *Libertia*: in these only the inner perianth-leaves, or petals, are coloured, the sepals being greenish; the styles also are filiform, not petaloid.

Compare with the above type any of the following, which are more or less commonly cultivated plants: *Gladiolus*, *Watsonia*, *Sparaxis*, *Ixia*, *Tigridia*, or *Crocus*. Nearly allied, but always having *six* stamens, are—*Galanthus* (Snowdrop), *Narcissus* (including Daffodils and Jonquils)—all the species of which are furnished with a crown, or tube-like prolongation of the perianth, called the **corona**—*Amaryllis*, *Leucojum* (Snowflake), &c.

25. New Zealand Flax (*Phormium tenax*).

In many of its features this abundant and most characteristic plant resembles the preceding type. It has a stout creeping rhizome, from which ascend tufts of very long, equitant, ensiform leaves, having parallel venation. The scape bears numerous panicled flowers, each cluster subtended by a spathe-like bract. Each flower has a perianth of 6 separate and almost similar dull-red-coloured leaves, which are fastened below the ovary (inferior). The base of the flower secretes a large quantity of very sweet nectar. The 6 stamens are attached to the lower part of the perianth-segments (perigynous), and have their anthers *dorsifixed* (*i.e.*, fastened by their back to the filament) and opening inwards (*introrse*) when ready to discharge their pollen. The superior 3-celled ovary contains numerous ovules arranged in two rows in the axis of each cell, and it bears a stout 3-angled style ending in a capitate obscurely-3-lobed stigma. The fruit is a more or less elongated and 3-angled capsule, which dehisces loculicidally by 3 valves, displaying a great number of closely-packed, shining, black, flat seeds. These have a thin membranous testa, and contain rather firm endosperm with a straight axile embryo. In the form and size of the capsule there is considerable diversity in different varieties of this plant, some having the pod as much as 6in., or even 8in. long, and narrow, while in other forms they are very short and thick.

If plants in full flower are observed, it will be seen that they are visited continually by birds, which thus serve to cross-fertilise them. Besides tuis and korimakos or bell-birds, kakas and various species of parrakeets may frequently be seen sipping the nectar out of the flowers, in doing which the feathers at the base of the bill become thickly dusted with the orange-yellow pollen.

(*a.*) Compare with the foregoing the common Cabbage-tree (*Cordyline australis*). This differs in many respects from *Phormium*—*e.g.*, the arboreous stem, bearing at its apex

numerous linear leaves, which, however, are not equitant, and its large many-branched panicles of fragrant white flowers. These have also 6 nearly separate perianth-leaves, 6 perigynous stamens, a 3-celled superior ovary with a single style 3-lobed stigma and numerous ovules. But in maturing, the pericarp becomes somewhat succulent, so that, instead of being capsular, the fruit is a whitish berry containing angular black seeds. There are several species of *Cordyline* in New Zealand, showing interesting gradations of stem- and leaf-structure.

(*b*.) In nearly all parts of the colony where bush occurs, species of *Astelia* are to be found. The commonest of these in the North Island is *A. solandri*, while in the South Island *A. grandis* is one of the most familiar. The former species chiefly grows on tree-trunks, the latter on the ground. They are readily recognised by their large linear flax-like leaves, which are commonly strongly-nerved, and are more or less clothed with silky or chaffy hairs on their sheathing-bases. The flowers are produced in large panicles near the bases of the leaves, and in the number and arrangement of their parts are similar to the preceding plants, but the species are strictly diœcious, the ♂ flowers having no pistils, while the ♀ have at the most only rudiments of stamens (staminodia). In some, also, two of the three carpels remain almost undeveloped, so that the ovary becomes reduced to one cell only, having parietal placentation; but as a rule all three cells are developed, when of course the placentation is axile. The fruit is a berry, often more or less sunk in the perianth. In *A. solandri*, according to Mr. Kirk, the flowers are lemon-coloured, and are produced in January or February, followed in June or July by bright-crimson fruit. *A. grandis* blooms about October. Its flowers are dark-green in colour, and are produced in short thick panicles among the leaves, and are therefore easily overlooked; but they are very fragrant, and produce a considerable quantity of nectar, thus rendering them very attractive to many species of Diptera (flies), which no doubt are the cross-fertilising agents. The bright-orange berries are ripe in February and March.

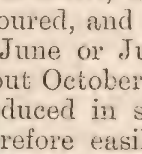

Fig. 174. Ovary of *Anthericum*, trans. section (mag.).

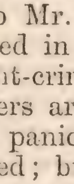

Fig. 175. Dehiscing (loculicidal) capsule of *Anthericum*.

(*c*.) Other interesting species of this type are common in many parts of New Zealand, such as *Arthropodium*, with its panicles of pretty little lily-like white flowers, and *Anthericum*, or Maori Onion, a very abundant plant in nearly all elevated open parts of both Islands,

and easily recognised by its racemes of bright-yellow asphodel-like flowers. In the former the filaments are exquisitely bearded in their upper half by bright-pink and orange hairs, which are produced downwards into two horn-like processes.

Fig. 176. Seed of *Anthericum*, long. section (mag.).

Fig. 177. Flower of *Arthropodium* (mag.).

Fig. 178. Stamen of *Arthropodium* before dehiscence (mag.).

Fig. 179. Stamen of *Arthropodium* after dehiscence (mag.).

Compare with all these, species of any of the following genera which are commonly met with in cultivation: *Lilium* (Lily), *Tulipa* (Tulip), *Hemerocallis* (Day-lily), *Polianthes* (Tuberose), *Agapanthus*, *Tritoma* (Red-hot Poker), *Muscari* (Grape Hyacinth), *Scilla* (Squills), *Allium* (Onion, Leek, or Garlic), *Hyacinthus* (Hyacinth), *Ornithogalum* (Star of Bethlehem), &c.

(*d*.) The common Supple-jack (*Rhipogonum scandens*) belongs to a somewhat different type. The long tough climbing stems bear simple petioled 3-nerved leaves, having *netted venation*. The flowers have six perianth-leaves, 6 stamens, and a 3-celled ovary, which ripens into a scarlet berry. In flower, each cell of the ovary contains a single ovule, but in ripening either one or two of the ovules become atrophied, so that, as a rule, the berry contains only one seed. This has a thin testa and hard endosperm, enclosing a very small embryo.

26. Orchids.

Several genera of orchidaceous plants are common in New Zealand, but they are usually so different in appearance from one another that it becomes a somewhat difficult matter to select typical species. In no group of plants are there so many interesting and varied contrivances to bring about cross-fertilisation, and therefore to the student who has studied the types we have already described orchids will repay close examination. While it is impossible in a short space to go into details of many of the forms, it will be advisable to describe one or two somewhat fully.

Dendrobium cunninghamii is a species to be found in many parts of both Islands, particularly near the sea-coast. It is a

true **epiphyte**,* growing in large tufts on tree-trunks or rocks, and having only aerial roots, which rot away if buried in the soil. Its branching stems are thin, wiry, and polished, and bear numerous narrow striated 3-nerved leaves, arranged in two rows (*distichous*). In December or January its pretty white or pinkish flowers are produced, on slender pedicels, in 2- or more-flowered racemes, which spring from the axils of

Fig. 180. Flowering branch of *Dendrobium cunninghamii.*

Fig. 181. Ovary of *Dendrobium*, trans. section (mag.).

Fig. 182. Flower of *Dendrobium*, long. section.

the upper leaves. Note first the inferior ovary, which is 1-celled, and contains an immense number of minute ovules on 3 parietal placentæ. Above this is the perianth, made up of 6 leaves, while the centre of the flower is occupied by a **column** shaped somewhat like the letter **J**. Of the three outer perianth-leaves, or *sepals*, one stands up behind the upright part of the column, while the other two are lateral, and have their bases adnate to its produced part. Of the three inner leaves, or *petals*, two are lateral, while the third faces the upright part of the column. This petal is nearly always remarkably formed in orchids, and is called the **labellum**, or lip. In the present species it is 3-lobed, the small lateral lobes being usually of a bright-crimson colour, while on the central lobe is a longitudinal series of 5 yellow plate-like ridges. The labellum is jointed on to the tip of the produced part of the column, and is easily bent back—*e.g.*, by the weight of an insect; but it is sufficiently elastic to spring up again when the pressure is removed. When all the perianth-leaves have been removed only the column is left, standing on the summit of the ovary. The produced portion of this, on which the labellum stands, ends in a green glandular swelling, at the base of which a drop of nectar is excreted. The up-

* Gr. *epi*, upon; *phyton*, a plant.

right portion of the column ends in a single *anther.* The pollen, instead of lying in two or more cells or cavities as dust, is united into masses called **pollinia** in all orchids. In this species there are 4 pollinia in the anther; each is in the form of an oblong flattish

Fig. 183. Column of *Dendrobium*, seen from the side (mag.).

Fig. 184. Column of *Dendrobium*, front view (mag.).

Fig. 185. Pollinia of *Dendrobium*, withdrawn on a needle (mag.).

plate, and these unite in pairs to form a strap-shaped *caudicle,* or thong, by which they are joined in front to a viscid gland on the rostellum. This **rostellum** is the beak, or point, of the column, which projects out in front of the anther. Below it, and forming a nearly square viscid depression or pit in the front of the column, facing the labellum, is the *stigma,* which is imperfectly 2-lobed. The sides of the column near the top are slightly inflated in a wing-like manner.

The flowers usually hang in such a manner that the labellum is on the lower side, so that if an insect alight on it it hangs down and exposes the nectar-gland. As the insect moves forward to sip the nectar, the elasticity of the labellum tends to press it against the column. In moving back out of the flower it brushes the viscid rostellum with the top or back of its head, and in this way removes usually all four of the pollinia, which, however, by the mode in which they are withdrawn from the anther, are pulled forward a little on the insect's head. In visiting the next flower these pollinia are in such a position by this depressing action that, as the insect advances its head, they miss the rostellum, but are thrust below it into the stigmatic cavity. It will be easily seen that self-fertilisation of these flowers is absolutely impossible in a state of nature.

The ovary matures into a capsule, which dehisces by 3 placentiferous valves; these separate away above and below, leaving the midribs of the carpels standing. The seeds are very minute and light, in appearance like very fine sawdust, and are readily dispersed by the wind. Owing to their size, their structure is only made out with great difficulty. They have a very loose, reticulated testa, enclosing a solid, apparently structureless embryo.

Another common epiphyte is *Earina*, two species of which occur in the bush: the flowers are small, wax-like, and fragrant.

Fig. 186. Part of panicle of *Earina mucronata*.

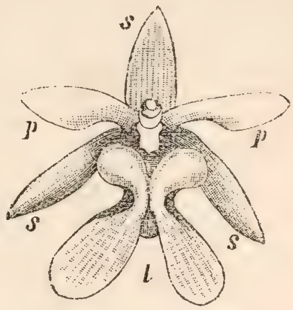

Fig. 187. Flower of *Earina*, front view (mag.). *s*, sepals; *p*, petals; *l*, labellum.

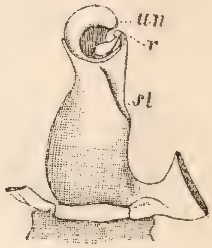

Fig. 188. Column of *Earina*, side view (mag.). *an*, anther; *r*, rostellum; *st*, stigmatic cavity.

(*a*.) A singular form of flowers prevails in the genus *Pterostylis* (so named from the winged column). The plants are terrestrial herbs, bearing grass-like sheathing-leaves, springing from underground tubers, which are annually produced. In most of our species each plant bears only one rather large green flower. In this, the upper sepal and lateral petals are more or less bent or united together to form a boat-shaped hood, while the two lateral

Fig. 189. Flower of *Pterostylis banksii* in long. section.

Fig. 190. Labellum of *Pterostylis*.

Fig. 191. Column of *Pterostylis*, side view. *an*, anther; *st*, stigma.

sepals are united in front. The labellum is rather small and narrow, and is nearly all enclosed by the other leaves of the whorl, only its apex projecting. It is fastened by a small claw to the basal projection of the column, while its lower end is produced downwards into a short curved appendage.

The column is elongated, and has near its upper extremity two quadrangular wings, produced forwards at right angles. The anther is terminal, 2-celled, and contains four granular pollinia. The stigma is a 2-lobed elongated surface on the face of the column, just below the projection of the wings. When an insect enters the flower and crawls to the bottom, the labellum moves forward and shuts it in, so that it can only escape by walking up the column and out between the wings. But in doing so it has first to pass the stigma, and then the rostellum, in touching which it will carry away with it one or more of the pollinia. If it visits a second flower the same process will be repeated, but this time the stigma will be smeared with the pollen brought from the first-visited flower.*

Fig. 192. Column of *Pterostylis*, front view. *an*, anther; *r*, rostellum; *st*, stigma.

(*b*.) The structure of orchid-flowers is apparently so different from that of the two types previously examined that it is not easy at first sight to see any relationship between them. In both iridaceous and liliaceous plants trimerous symmetry prevails in all the parts, there being 6 perianth-leaves, 3 or 6 stamens, and usually a 3-celled ovary. In orchids we also find the 6-leaved perianth and 3 placentæ in the ovary; but the staminal whorl appears to be defective. At the same time one of the perianth-leaves—viz., the labellum—is always different in appearance from the others, while, further, there are in most orchids peculiar outgrowths, both of the labellum and column, which are not explicable by superficial examination. But by careful dissection it has been shown pretty conclusively that the flower consists theoretically of 5 whorls of 3 parts each—viz., 3 sepals, 3 petals, 6 stamens, and 3 carpels. By tracing out the 15 groups of spiral vessels which pass up into the flower, Darwin (whose

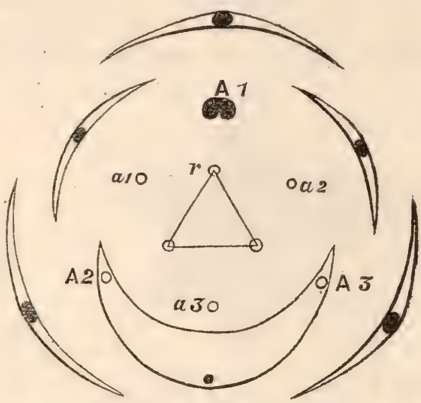

Fig. 193. Theoretical floral diagram of an Orchid flower (after Darwin).

* The structure and development of this group of flowering plants is fully treated of in Darwin's "Fertilisation of Orchids." Papers on the fertilisation of New Zealand species, by Mr. T. Cheeseman and the present writer, will be found in the "Transactions of the N.Z. Institute," Vol. v., p. 352; vii., p. 349; ix., p. 542; x., p. 353; xi., p. 418; and xiii., p. 291.

diagram is reproduced here) came to the following conclusions: Of the 6 staminal organs originally present, one (A_1) of the outer whorl is represented by the fully-developed terminal anther of the flower, the other two (A_2 and A_3) of the same whorl combine with the lower petal to form the labellum. Of the inner staminal whorl, a_1 and a_2 pass up the sides of the column, sometimes appearing as outgrowths or staminodia, as in *Thelymitra*, a common New Zealand genus of orchids, in which the flowers are nearly regular. (In Ladies' Slipper — *Cypripedium* — a genus not uncommonly found in cultivation, A_1 is represented by a shield-like expansion on the top of the column, while a_1 and a_2 form fully-developed stamens.) The third stamen of the inner whorl is quite undeveloped, the spiral vessel passing up the front of the column. Of the innermost whorl of three spiral vessels, two can be traced to the stigmatic faces, while the third, *r*, ends in the rostellum. Although this view is only theoretical, yet it is so inherently probable, and affords such an insight into the modifications which take place in the development of floral organs for definite purposes, that it is well worth studying. We should judge from it that the progenitors of all orchids had regular flowers with perfectly trimerous symmetry, but that their mode of fertilisation became more and more specialised, until at last they became dependent on certain kinds of insects to perform this necessary work for them. In course of time species of some genera, such as *Thelymitra*, *Microtis*, and *Prasophyllum*, appear to have retrograded in development so far as to become self-fertile once more; but the majority of orchid-flowers are quite

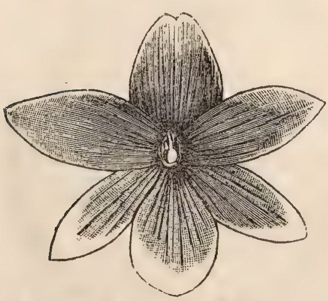

Fig. 194. Flower of *Thelymitra pulchella*, front view.

Fig. 195. Column of *Thelymitra*, side view (mag.).

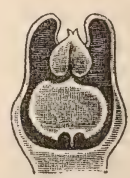

Fig. 196. Column of *Thelymitra*, front view (mag.).

incapable of self-fertilisation. In the first-named genus the flowers tend to revert to regularity of form as far as the perianth is concerned, but in other respects retain the typical orchid-structure.

26. Sedge (*Carex* sp.).

Sedges of many kinds are abundant in New Zealand, so that it is a difficult matter to specify to the inexperienced observer exactly what kind is intended. The description given is that of one of the commoner species of *Carex*—*e.g.*, *C. forsteri*.

* The plant is commonly mistaken for a grass, but may be readily distinguished by the following conspicuous characters: In grasses the stem, which in all these plants is called a **culm**,† is usually round and hollow except at the joints; the sheaths of the leaves are split to the base; while at the junction of the blade and its sheath there is usually a membranous scale or stipule called the **ligule**.‡ In sedges, on the other hand, the culm is usually 3-angled, and is solid throughout; the leaf-sheaths are not split, but are continuous round the culm; while, lastly, there is no trace of a ligule. These characteristics are generally sufficient in themselves to enable a collector at once to decide whether a grass-like plant is a true grass or a sedge. The floral and fruit characters are, further, quite distinct.

Fig. 197. Flowering branch of *Carex lucida*.

The inflorescence of a *Carex* consists of two kinds of flowers, ♂ and ♀, arranged in spikes, commonly, however, termed **spikelets**—which are usually borne on one culm. In *C. forsteri* there are generally about 5 or 6 of these spikelets, the upper one or two consisting of ♂ flowers only, those below of ♀ flowers, with ♂ flowers at their upper or lower extremities. The plants are thus monœcious. Each flower is placed in the axil of a small dry scale-like bract called a **glume**,§ which in most cases has a strong

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* The species figured (for convenience of size) is *C. lucida*. In *C. forsteri* the spikelets are from 2in. to 4in. long.

† Lat. *culmus*, a stalk.

‡ Lat. *ligula*, a strap or thong.

§ Lat. *gluma*, the husk of corn.

median nerve, or midrib. Each minute ♂ flower consists of 3 stamens, having very slender flattish filaments and long narrow basifixed anthers. There is no perianth and no ovary. (To see these characters properly, the flowers require to be dissected in a drop of water under a simple microscope.) The ♀ flowers are much larger than the ♂, and are also placed in the axil of a glume. Each is enclosed in a false perianth or **utricle**,* urceolate in form, and terminating above in a slender 2-pointed beak, from which project the points of the 3 stigmas. Within the utricle is a single 3-angled ovary, bearing one style divided above into 3 stigmatic arms, and containing one erect ovule. The ovary ripens into an achene, which remains enclosed in the utricle. The seed is seen in longitudinal section to have a minute embryo at the base of, but enclosed by, mealy endocarp.

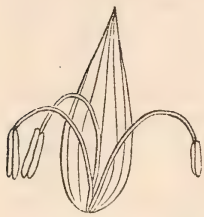

Fig. 198. ♂ flower of *Carex* (mag.).

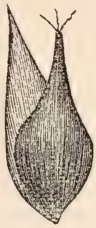

Fig. 199. Ripe utricle of *Carex* (mag.).

Fig. 200. Carpel of *Carex*, removed from utricle (mag.).

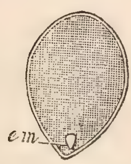

Fig. 201. Seed of *Carex*, longitudinal section (mag.). *em*, embryo.

Considerable variations from this type are to be found in other sedges and cutting-grasses.

Thus, in the large marsh-sedges of the genus *Cyperus*, so common throughout the North Island and parts of the South, the spikelets are crowded into spikes, and these again are aggregated into umbels, giving the plants a striking and characteristic appearance.

In others, as some species of *Schœnus*, *Scirpus*, and *Eleocharis*, there is a perianth present in the flowers, consisting of 3 or 6 elegant hypogynous bristles.

In the large cutting-grasses of the genus *Gahnia*, the filaments elongate considerably after flowering, twisting into a mass in which the achenes are entangled and suspended. In them the pericarp is thick and polished, and so hard as to resist almost any knife-edge.

Lastly, in the flowers of *Uncinia*, a genus which in many

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* Lat. *utriculus*, a bladder.

respects closely resembles *Carex*, a long bristle arises from under the ovary within the utricle, projecting considerably beyond it, and bearing a strong barb or reversed hook at the tip. This is evidently a contrivance for the distribution of the seed by means of passing animals, and it serves its purpose most efficiently.

Fig. 202. Spike of *Uncinia*, with ♂ flowers above and ♀ flowers below.

Fig. 203. Utricle of *Uncinia*, with barbed spine (mag.).

27. Grasses.

The structure of a typical grass is perhaps most readily comprehended by the examination of the common Oat (*Avena sativa*). The external and most manifest characters have already been pointed out—viz., the hollow rounded culm, closed at the joints; the sheaths of the leaves split to the base; and the presence in most cases of a ligule at the junction of the blade and sheath.

The flowers are collected into small spikelets, and these are arranged on slender pedicels in open panicles, the form of which varies considerably in different varieties of oats. Each spikelet bears externally two scale-leaves or glumes, which are usually called the **empty glumes**. As a rule two flowers are enclosed in these outer glumes, one large and fully developed, the other smaller, and there is often in addition the rudiment of another flower present. Each flower is also enclosed in two scale-leaves: the outer and larger one, which overlaps the inner by both its edges, is called the **flowering-glume**, and it generally

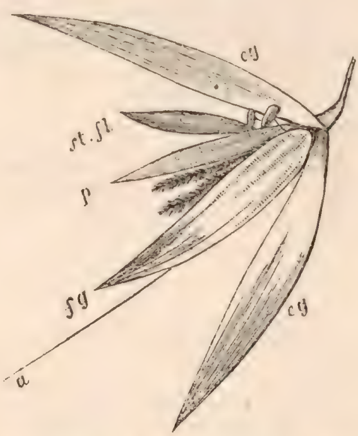

Fig. 204. Spikelet of Oat (mag.). *c.g*, empty glumes; *f.g*, flowering glume; *a*, awn; *p*, palea; *st.fl*, sterile flower.

has an *awn* or bristle springing from the middle of the back and projecting out of the spikelet; this is probably only a much-produced midrib. The narrow, erect inner scale-leaf is the **pale*** or **palea.** The flower itself has an extremely rudimentary perianth, consisting of two minute scales called **lodicules,**† 3 stamens with dorsifixed versatile anthers, and a 1-celled ovary containing a single ovule and bearing 2 beautifully plumose stigmas.

Fig. 205. Flower of Oat, with the flowering glume removed (mag.). *pal*, palea; *lod*, lodicules.

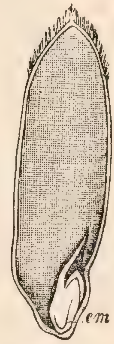

Fig. 206. Caryopsis of Oat, in longitudinal section (mag.). *em*, embryo.

As the ovary ripens the flowering-glume and pale harden considerably, and the former closes firmly round the fruit. This fruit, which is popularly considered to be the seed only, is a kind of achene technically known as a **caryopsis.**‡ Its pericarp is so thin as to be almost imperceptible, and it is closely adherent to and amalgamated with the almost equally imperceptible testa. The mass of the seed consists of somewhat hard floury endosperm, on the outside of the base of which the embryo is attached. This shows *one* well-developed cotyledon, a plumule, and a radicle. If the grains be soaked for a few hours and allowed to germinate, it will be seen that the radicle does not elongate into a tap-root, as that of the bean does, but that several root-fibres spring from it, each surrounded at its base by a small sheath.

The structure of this sheath should be carefully compared with that of a *Carex,* as the differences are very considerable.

There are very many kinds of grasses in New Zealand, showing considerable diversities of structure, but, in addition to the Oat, the most readily studied are the larger-flowered kinds, like Wheat and Barley. In all the species found here the differences are in details only, not in essential features.

In Wheat (*Triticum sativum*) the spikelets are arranged in a compound spike. The empty glumes are rather short and

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* Lat. *palea*, chaff.

† Lat. *lodicula*, a small coverlet.

‡ From two Greek words signifying that it resembles a nut.

unequal in length, and each spikelet bears 4 or 5, or sometimes more, flowers. A similar structure prevails in Rye-grass (*Lolium perenne*), only the upper flowering-glume is missing altogether.

In Barley (*Hordeum vulgare*) the spikelet contains only one flower, both the empty glumes and the flowering-glume are awned, and the palea is closely adherent to the fruit.

The relation of the flowers of grasses to those of other monocotyledons is not at first sight apparent, but the examination of those forms, such as Bamboo, which have undergone less modification than our ordinary grasses, shows how the present structure has been arrived at by suppression of various parts. In a typical monocotyledon such as Lily the flower consists of fifteen floral leaves, arranged in five whorls. In Bamboo the flower is quite regular, but there are only twelve parts—viz., 3 perianth-leaves, 6 stamens, and 3 carpels. In ordinary grasses (*e.g.*, Oats) not only is the outer whorl absent, but the posterior leaf of the inner whorl is also suppressed, while the two which are present are reduced to minute scales (the lodicules). Similarly, the 3 stamens of the inner whorl and the anterior carpellary leaf are wanting. This structure will be made more clear by an examination of the accompanying floral diagrams.

(A.) (B.) (C.)

Fig. 207. Theoretical diagram of (A) Bamboo, (B) most Grasses, (C) Nardus. (After Sachs.)

CHAPTER VII.

Modifications of Organs, etc., for Special Purposes.

In the preceding chapters incidental reference has been made and attention drawn to various modes in which plants have their stems, leaves, stipules, and other organs altered to serve different purposes. Various modes of, and devices for securing, cross-fertilisation of the flowers and distribution of their seeds have been mentioned. It will, however, be useful here to summarise a few of the principal facts learned, and to supplement them by mention of other interesting and remarkable modifications.

Leaves have for their principal function the process of conversion of carbon-dioxide (carbonic-acid gas) and water into starch, with evolution of oxygen gas, and for this purpose their usual construction is that of a framework of ribs and veins on which their softer green tissue is spread. The chief function of **stems** is to support the leaves and the reproductive organs. But we have already seen that many stems have lost this function, or have modified it so as to gain the same end with a minimum development of supporting-tissue. This is frequently attained by the habit of twining common to so many plants (*e.g.*, French Beans), a habit which is sometimes aided by roughnesses on the stems (Hop, &c.). In other cases we find (1) recurved prickles developed on the

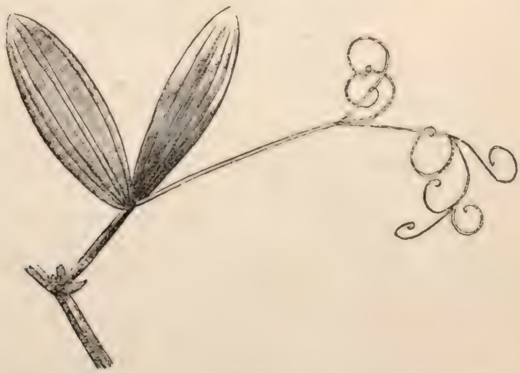

Fig. 208. Tendril-bearing leaf of Sweet Pea.

outer skin or epidermis (*Rubus australis*); (2) sensitive curving petioles (*Clematis*); or (3) specially-developed organs for the purpose of climbing, called tendrils. These tendrils are sometimes formed of modified branches (Grape-vine), or midribs of leaflets (Pea), or, apparently, in some cases, of stipules (Melons, Cucumbers, &c.). In many plants, branches—which are ramifications of the stem—are produced into spines (Hawthorn and *Discaria*), acting as defensive organs to protect the plant possessing them from herbivorous animals. The same end is probably gained by spiny stipules (False Acacia), by spiny leaves (Holly), and by the rigidity of stems and leaves which characterizes many mountain-plants. Very considerable development of hairs on the epidermis, as in the Raspberry, serves probably the same end; but most commonly this hairiness (*e.g.*, in *Celmisia coriacea*), as well as the extremely coriaceous nature of the leaves of many plants (*Veronica tetragona*), serves to resist the attacks of insects. This latter function is chiefly performed by epidermal developments of this nature, sometimes by glandular hairs (*Petunia*) or by general viscidity (*Celmisia lindsayi*), and in other cases by something disagreeable in the juice (Dandelion and Lettuce).

The development of the leaf has in some cases taken the extreme form of catching and digesting nitrogenous substances —as, for instance, the bodies of insects, seeds, &c. Viscid parts of plants, or those parts with glandular hairs, appear to be avoided by insects; but it is probable that in some cases, when insects, seeds, or any other things containing easily-removable nitrogenous substances are caught upon glandular hairs, these latter have the power of absorbing such substances and utilising them for the use of the plant. It is perhaps in this way that those remarkable developments have arisen which occur in Sundews and Venus's Fly-trap. Sundews (*Drosera* of various species) are plants growing in marshy or damp ground, whose leaves are covered above and on their margins with glandular hairs — hence their name. When a small insect alights on the leaf — and the leaves are brightly coloured, apparently so as to attract insects—it at once becomes clogged by the viscid material on the hairs, and its struggles to escape only serve to fasten it more securely, and in a short time it perishes. But in an hour or two after its capture the hairs in its neighbourhood commence to bend their

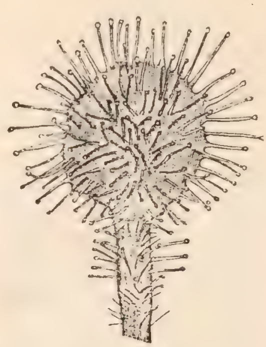

Fig. 209. Leaf of *Drosera spathulata* (mag.).

heads towards it, and all the glands which can reach it pour out a peculiar secretion upon it. This secretion contains a ferment which acts much as the digestive fluid of animals

Fig. 210. Leaf of *Drosera binata*.

does, and in a longer or shorter time, according to the size of the insect, all its soft parts are dissolved away and apparently absorbed by the plant. Any readily-decomposable nitrogenous substance, animal or vegetable (*e.g.*, raw or cooked food, or bread), serves to similarly excite these glands.

More specialised still is the Venus's Fly-trap (*Dionæa muscipula*), which is allied to *Drosera*, but in which the leaf-blades act as a trap. The midrib is strongly keeled, and the margin furnished with serrated processes. Each side of the blade bears three stiff hairs, and if anything touches one of these the two sides close together and catch the intruder. The leaf-

surface is covered with secreting glands, as in *Drosera*, and which possess similar digestive powers.

Fig. 211. Leaves of *Dionæa*, shut and open.*

Several other plants have the same properties as Sundews, though probably not to the same extent. Thus, in a few swampy districts in different parts of this colony, small semi-aquatic plants, called Bladderworts (*Utricularia*), are to be found. In these the submerged branches bear small bladder-like structures, which are evidently—to judge from their position—modified leaves. These bladders, which are hollow, have an opening by means of which small aquatic animals can enter; and it is rare to find a bladder without one or more minute water-fleas or insects in it. Sometimes they are quite full of animal remains in various stages of decomposition. Apparently, the want of dissolved oxygen in the water contained inside the bladders proves fatal to the animals which enter, for, once they are in, they never seem able to get out again, but die where they are caught. Probably, also, their bodies decay and furnish a small supply of nitrogenous food to the plant, for the interior of the bladders is furnished with peculiar cells standing together in fours on short stalks, and whose function is apparently absorptive.

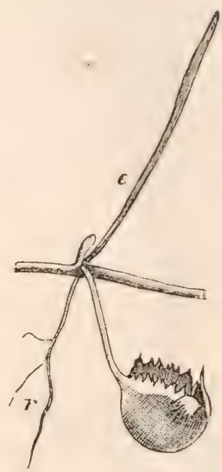

Fig. 212. Submerged branch of *Utricularia monanthos* (mag.).

* The sensitive hairs on the inner faces of the leaf-blade have been omitted in the drawing.

The different forms of Pitcher-plants have also got the whole or some part of their leaves modified for a somewhat similar purpose. Thus, in *Sarracenias*, which occur chiefly in North America, "a sugary secretion exudes at the mouth of the pitcher, and attracts the insects, which descend lower in the tube, where they meet with a belt of reflexed hairs, which facilitate their descent into a watery fluid that fills the bottom of the cavity, and at the same time prevent their egress." *

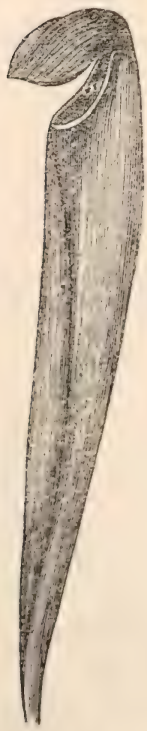

Fig. 213. Pitcher of *Sarracenia variolaris* (reduced). (After Gray.)

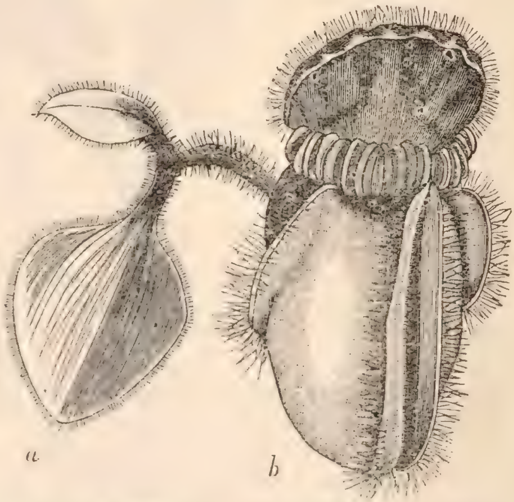

Fig. 214. Pitcher of *Cephalotus follicularis*. (After R. Brown.)

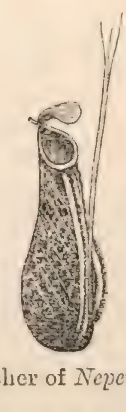

Fig. 215. Pitcher of *Nepenthes* (reduced).

Cephalotus, which occurs in South-west Australia, appears also to have a kind of trap-arrangement for catching unwary

* Sir J. Hooker, in Le Maout and Decaisne's "Descriptive Botany," p. 214.

insects. Similarly, the very perfect pitchers of *Nepenthes*—a genus which occurs chiefly in the Malaysian region—have been shown by Sir J. Hooker to exert a very powerful digestive action upon nitrogenous matters.

Parasitism, or the peculiar habit which certain plants have acquired of growing upon other plants and abstracting their nourishment from them, is possessed by several species of plants in varying degrees of perfection. Thus, some are called root-parasites, because they establish themselves when young on the roots of their host, and are thus saved the necessity of producing roots of their own.

The only parasite* of this class known to occur in New Zealand is a most remarkable and rare species—*Dactylanthus taylori*—which appears to have been found only in two localities in the North Island, and which grows on the roots of *Fagus* (Native Birch) and *Pittosporum* (Mapau).

An English root-parasite, *Bartsia viscosa*, has been introduced into parts of the colony, but it does not show any parasitic tendency under its altered surroundings.

A remarkable kind of parasitism has been acquired by the Dodders (*Cuscuta*), and by *Cassytha*, a genus allied to the laurels. One species of *Cuscuta* is indigenous to this country, and two or three have been introduced from Europe; *Cassytha* is also represented by a local species. The plants of the genus *Cuscuta* are allied to convolvuluses, and, like them, each begins its existence as a herb with a twining stem. As soon as the young stem comes into contact with the stem of a plant suitable for a host, it twines round it, and at the surfaces which are in contact it develops small sucking discs. When a sufficient number of these have been produced the root in the soil dies away, and in future the parasite lives upon its host. *Cuscuta* is quite destitute of leaves, and consists only of thin thread-like stems, on which clusters of flowers and fruit are produced. Its leafless character is probably due to the fact that its suckers can only extract from the plant on which it grows those portions of the sap which have already been assimilated.

The most complete kind of parasitism is that found in Mistletoes, of which several species of *Loranthus*, *Tupeia*, and *Viscum* occur in New Zealand. These plants have lost the power of growing in soil. The seed is dropped by a bird on the branch of a tree, and germinates there, the radicle penetrating the bark. The plant thus established becomes quite amalgamated with its host. But it differs from *Cuscuta*

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* In Europe plants of the genus *Euphrasia* (or Eyebright) are usually parasitic on roots; apparently this peculiarity has not been observed in any of the New Zealand species of the genus.

in possessing leaves, presumably because its vessels, penetrating into the internal tissues of the host, abstract from it unassimilated sap on its way from the root to the leaves, which sap the parasite has to assimilate in its own leaves.

Fig. 216. *Viscum lindsayii*, *(a)* a Mistletoe parasitic on *(b)* a Rata—*Metrosideros hypericifolia*.

The modifications of the different parts of the flower have been somewhat fully referred to under the different types. To recapitulate briefly: The function of the calyx appears to be protection; that of the corolla chiefly attraction of insects; of the stamens the production of pollen which contains the male fertilising element; and of the carpels the production of ovules which contain the female element.

Probably sepals have been developed from ordinary foliage-leaves, as may be inferred from their position, form, and (usually) green colour; hence their union into a synsepalous calyx is a later development. Occasionally, as in *Fuchsia*, they become petaloid and coloured, the petals being correspondingly reduced in size; in some genera (*Clematis*, *Anemone*, &c.) the petals are completely replaced by them. They are frequently persistent, and either act as protection to the fruit (*Veronica*), or become succulent and brightly coloured (Snowberry). In composites and a few allied plants the calyx is modified into a *pappus*.

The petals have probably been developed from stamens—at least, this view is strongly supported by the fact that in cultivation stamens usually tend to turn into petals, and this occurs normally in many roses, water-lilies, &c. The great diversities of form and colour found in the corollas of different plants, and which serve—along with their scent and develop-

ment of nectar—as baits for different kinds of insects, are usually closely associated with special forms of the stamens and pistil, and have relation to the mode of fertilisation of the flower.

While the majority of flowering plants bear hermaphrodite flowers—*i.e.*, those containing both stamens and pistil—it is very commonly the case that fertilisation of the ovules is only accomplished when pollen from a different plant of the same species is brought to the stigma. Many hermaphrodite flowers are quite capable of self-fertilisation, but appear to benefit by crossing, the resulting seeds usually producing very fine and strong plants. It has further been shown that, even among such plants, pollen from others of the same species appears to have a more powerful fertilising action on the stigma than other pollen from the same flower has, even when the latter has been applied first. In a large number of species the pollen is not capable of fertilising the flowers from which it is taken, and in these cases cross-fertilisation must take place. And, as if to insure that self-fertilisation will not occur, numerous contrivances have arisen to render it difficult or all but impossible. These have been already referred to in detail, and need only be mentioned again here. Among these contrivances are (1) the more or less complete separation of the essential organs in monœcious and diœcious plants; (2) dichogamy, or the maturing of the anthers and stigmas at different times; and (3) heterostylism, or the unequal lengths of stamens and styles; besides innumerable individual modifications of structure, all tending in the same direction. In violets—and no doubt in many other plants—we see adaptations for producing seed by self-fertilisation in cleistogamic flowers, in addition to those seeds which are produced by crossing in the ordinary flowers of the plant.

The modifications of the fruit are chiefly in the direction of insuring distribution of the seeds. The chief agencies which are taken advantage of in this work are those of water, wind, and animals, besides which a few plants have acquired the power of scattering their seeds more or less perfectly by some mechanical contrivance.

Water, particularly in running streams, serves to carry many fruits and seeds from higher to lower levels, and these frequently become stranded, and germinate. But, with the exception of a few aquatic or semi-aquatic plants, there are very few which have become specially modified to suit this mode of dissemination. One of these few is the Coconut, whose fruits can withstand soaking in sea-water for some months.

Wind is a most efficient agent in scattering seeds. In

Clematis the style remains persistent on the achene, and, besides, becomes elongated and very feathery. In Composites and other allied forms (*e.g.*, some Valerians) the calyx-tube is persistent on the top of the achene, and the limb develops into a *pappus*, as in Thistle, Groundsel, Dandelion, &c. The

Fig. 217. Feathered achene of *Clematis*.

Fig. 218. Fruit of Dandelion, with pappus.

Fig. 219. Seed of *Epilobium*.

same method of dissemination is attained in *Epilobium* and *Parsonsia* by the occurrence of long hair-like plumes on the seeds themselves. In other plants wing-like expansions serve

Fig. 220. Seed of *Parsonsia*.

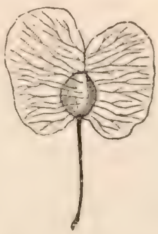

Fig. 221. Winged fruit of *Dodonœa viscosa*.

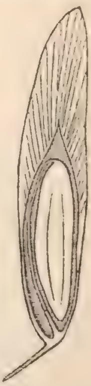

Fig. 222. Winged fruit of Ash, long. section.

Fig. 223. Samara of Maple.

to catch the wind, and thus the fruits or seeds are transported considerable distances. This is the case in the winged capsule of *Dodonœa viscosa*, and in the flattened seeds of New Zealand Flax (*Phormium*). It is

common in many foreign plants, the flattened siliqua of Honesty (*Lunaria*), the winged nut of the Ash, and the paired winged nuts (samaras) of Maples (*Acer*) being familiar examples.

Animals unconsciously serve to distribute many species of plants. Thus, in many *Acænas* (Piri-piri) the calyx-limb is produced above the angles of the fruit into 4 spines bearing barbs at their tips, which catch on to passing animals. The same mode is attained in *Galium aparine*, an English plant naturalised here, by barb-like roughnesses of the pericarp; in the Bur-reed (*Sparganium*) and others by the spiny flower-heads, and in a less degree in the seeds of the Carrot, &c. In *Uncinia*, a remarkable and common Sedge, or cutting-grass, a specially-produced barbed bristle acts in a similar manner (p. 101). In many foreign plants—*e.g.*, *Martynia*—the fruits or seeds are furnished with hooked spines or processes by which they catch the hair or fur of passing animals. Such fruits and seeds frequently become a very serious pest in countries where they are abundant. Thus, in Cape Colony and Buenos Ayres the annual clip of wool is greatly depreciated in value by the frequent occurrence in it of such burs or spines.

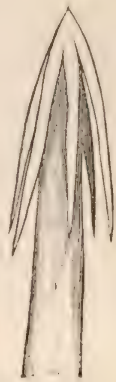

Fig. 224. Barb of calyx of *Acæna* (mag.).

Some seeds and fruits become strongly viscid, for the purpose, apparently, of enabling them to adhere to birds, and thus to be transported. This is probably the explanation of the remarkably viscid seeds of the Para-para (*Pisonia umbellifera*), and also of those of Mapau (*Pittosporum*). But certainly the most common modification of fruits for the purpose of bringing about distribution of their seeds is that by which they are rendered attractive to birds. These eat them, probably in many cases swallowing the seeds and passing them undigested; but most likely, in the case of the larger fruits, carrying them some distance away, so as, in unmolested peace, to eat the fleshy part and drop the stone. Most succulent fruits either have a hard stone or contain seeds with a hard testa, so that in either of these modes the pericarp becomes succulent externally (Plum, Cherry, Coprosma, &c.), and stony in the interior. Such fruits are extremely common in New Zealand, where they are popularly called berries. Truly baccate fruits, in which all the pericarp is succulent, and encloses one or more seeds, are also abundant: familiar examples are the Pepper-tree (*Drimys*), *Fuchsia*, *Aristotelia*, Poro-poro (*Solanum aviculare*), and others. In Tutu (*Coriaria*) the same object is attained by the per-

sistent petals becoming succulent, enclosing the achenes; in Snowberries (*Gaultheria*) by the succulent calyx; and in *Muhlenbeckia* and *Cassytha* by the succulent perianth, &c. In some genera — *e.g.*, in *Gaultheria*— every gradation may be traced between truly dehiscent dry capsules, and indehiscent berries enclosed in the succulent calyx. In several other cases it is not the fruit at all, but some

Fig. 225. Fruit of Snowberry.

Fig. 226. Fruit of *Muhlenbeckia* (mag.).

other part, which becomes succulent. Thus, in *Exocarpus* and the fruits of the familiar Red-, Black-, and White-pines and Totara—all species of *Podocarpus*—it is the peduncle bearing the nut which similates a drupe. In the Strawberry

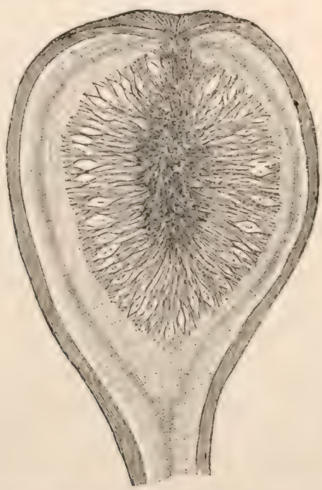

Fig. 227. Succulent receptacle of Fig, in longitudinal section.

it is the receptacle of the flower, in the Fig the common receptacle of the whole inflorescence become extremely concave, and in the Pine-apple it is the whole spike of flowers.

Again, in other species, as if the pericarp itself were not sufficiently attractive, the seed is more or less enclosed in an *aril*, which is an appendage growing up from the funicle. This is well seen in the capsular fruit of the Kohe-kohe (*Dysoxylum spectabile*), which opens to display its seeds enclosed in bright scarlet coats. The spice known as Mace is the dried aril of the Nutmeg.

Mechanical contrivances for scattering the seeds are not uncommon, but are not so conspicuous as the previous class. We are, however, familiar with elastic seed-pods in many plants—notably the Whin, or Gorse, and Broom. These may be heard cracking smartly on any dry sunny day in summer, and, if noticed, it will be seen that the seeds are ejected to a considerable distance. In Balsam (*Impatiens*) the capsule becomes very elastic inside, and when ripe cracks up along all its five valves at once with a peculiar twisting movement. In Woodsorrels and Shamrock (*Oxalis*) the seeds are enclosed in elastic membranes, which rupture when touched, and thus throw the seed a distance of several feet.

All these numerous contrivances serve the same end—viz., the distribution of the seed, by which the chances of the species to survive in the intense struggle for existence always going on are greatly increased.

PART II.

PRINCIPLES OF CLASSIFICATION

AND

SYSTEMATIC BOTANY.

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PRINCIPLES OF CLASSIFICATION AND SYSTEMATIC BOTANY.

INTRODUCTION.

WHENEVER, in the pursuit of knowledge, we come in contact with a large number of isolated facts, we almost always try, whether consciously or not, to arrange these facts in some sort of order. We usually try to group them together or place them in some sort of sequence, and the more completely and perfectly we succeed in placing them so that their natural relationships are brought out, the more complete and perfect is our classification. This is true of all kinds of knowledge and of all classes of facts.

Hitherto in dealing with plants we have treated them as if they were all isolated and distinct from one another, or if, by the order we have followed, a kind of relationship has been pointed out, this has only been done in an indirect manner. A large number of facts concerning them has been accumulated, and if we are to make further progress we must try and arrange these facts, and see whether we cannot get some order out of them.

In trying to classify plants, or, indeed, any other group of organized structures, we may proceed on one of two methods. We may choose to construct a scheme of classification in which special prominence is given to any one set of characters alone, all others being treated as more or less subservient. This was the mode in which the old botanists went to work; but their schemes of classification necessarily always proved so unsatisfactory that new ones were constantly being brought forward. This method culminated in the scheme proposed by

the celebrated Swede, Karl von Linné (Linnæus), in 1751. Linnæus proposed to divide all flowering plants into groups according to the number and attachment of the stamens, placing, for example, all plants which had 1 free stamen in a class by themselves, those with 2 forming another class, those with 3 a third, and so on—24 classes (the 24th being flowerless plants) thus including all known plants. This Linnæan classification, as it was called, was such an immense improvement upon those which had preceded it that it was very generally adopted, and remained in common use almost to our own day. But from the first it must often have appeared to botanists (as, indeed, it did to Linnæus himself) that the method was, after all, a very imperfect and artificial one. Let us take an example from our New Zealand flowers, and we shall see that this is so. Thus, the flowers of the common Manuka (*Leptospermum scoparium*) are usually hermaphrodite, and have ∞ stamens; these would therefore be placed in the Linnæan class Icosandria (having flowers in which there are 20 or more perigynous stamens). But very frequently the Manuka bears on the same branch ♂ flowers without any pistil, and fruit from the previous year's flowers, which must therefore have been either ☿ or ♀. Such a plant is therefore polygamous, and should come under the Linnæan class Polygamia. Here, then, the same species evidently is made to belong to two different classes. Numerous other similar examples could be advanced, but the one adduced is sufficient to show the artificial nature of such a system.

But if, instead of thus seizing upon any one character as our basis of classification, we try to group our plants together according to their agreement in the greatest number of characters—in other words, if we take the affinities or most apparent relationships as our guide—we shall come to form a more or less natural scheme of classification. It is quite clear that, if all plants now living have descended from one common primitive form which existed untold ages ago upon the earth, then there is only one truly natural system of classification, which will show exactly the real relationship of every kind of plant to every other. But our actual knowledge is still so fragmentary that we do not know at all well what this relationship is, and we therefore only express what little we do know in a very imperfect manner, and this is all that our present systems amount to.

We will not attempt to go into all the reasons of our classification, or try to estimate the relative values of the different characters exhibited by plants, but we may attempt with some prospect of success to apply here the knowledge we have hitherto been acquiring. Let us commence by taking a number of the plants referred to in the first sixteen chapters

of Part I., and comparing them together. Suppose, for example, we take the buttercup, sweet-pea, and primrose (though almost any others will do just as well), and observe first of all the venation of the leaves—it is **netted.** Now compare these with the iris, lily, and oat (or other plants like these): the venation is **straight.** This is no mere coincidence; but we shall compare further: let us look at the flowers. The buttercup has 5 sepals, 5 petals, ∞ stamens, and ∞ carpels; the sweet-pea has 5 sepals, 5 petals, 10 stamens, and 1 carpel; and the primrose has 5 sepals, 5 petals, 5 stamens, and 5 carpels. The number 5 seems to be prominent among them; while if, instead of these, you had taken the wallflower or the fuchsia, you would have found 4 or 2 to be the prevailing number. On the other hand, in iris you find 6 perianth-leaves (= 3 sepals and 3 petals), 3 stamens, and 3 carpels; in lily 6 perianth-leaves, 6 stamens, and 3 carpels; while in the oat the perianth-leaves are reduced to 2, but there are 3 stamens and (1 carpel with) 3 styles. Here the number 3 prevails, and this will be found to be equally the case if you take other plants allied to those named. Let us carry this comparison further. Examine the seeds of the pea (or of the cabbage, &c.), and you find **two cotyledons,** or seed-leaves, and, though you cannot see these in the seeds of the buttercup and primrose, yet if you watch those seeds springing in the soil you will observe that as soon as they come above ground the young plants always exhibit two seed-leaves. Similarly observe the springing of any iris-, lily-, or oat-seed, and you will only observe **one cotyledon** coming up.

Now, the structure and characters of the reproductive organs are not so likely to alter under any change of circumstances as are the habit of the plant, the form of its leaves, sepals, petals, and other external parts, and therefore the former, though less conspicuous than the latter, have always been considered the most important features in classification. Recognising this fact, Antoine de Jussieu, a celebrated French botanist, and the chief founder of this system, divided all flowering plants into two great classes, called respectively after their most important characters, **Dicotyledons** and **Monocotyledons**; and all our more recent knowledge only tends to confirm the view that these two represent the two great primary natural divisions. You will find that the following characters as a rule are shown by the plants belonging to these classes:—

(*a*). Dicotyledons have—

(1.) Two seed-leaves.
(2.) Netted-veined leaves.
(3.) Parts of the flower in 2s or 5s.

(*b.*) Monocotyledons have—
- (1.) One seed-leaf.
- (2.) Straight-veined leaves.
- (3.) Parts of the flower in 3s.

Less prominent characters are as follows :—

(*a.*) Dicotyledons have—
- (4.) Leaves usually petiolate, or, at least, with the blade rarely sheathing.
- (5.) Radicle of the embryo developing directly into a tap-root.
- (6.) In woody plants the wood appears in annual rings, owing to the mode in which certain formative tissues of the stems are developed. (Ex. Broad-leaf or Rata.)

(*b.*) Monocotyledons have—
- (4.) Leaves usually with sheathing-bases.
- (5.) Radicle of the embryo remaining undeveloped, and having fibres growing out of its sheath, so that the first root is fibrous.
- (6.) In woody plants no annual rings are visible. (Ex. Cabbage-tree.)

You will come across exceptions to these features: thus, some Dicotyledons have more than two seed-leaves (*Persoonia*), and sometimes some of the parts of the flower appear to be in 3s (as in Dock, some Wattles, &c.) ; but these exceptions are not so numerous or so important as to overthrow the general rule. So also there are Monocotyledons with netted-veined leaves (Supple-jack), and some with fewer parts to their flowers than 3s, while others have their parts in 2s or 4s ; but these exceptions are even fewer. So we may accept the above as our primary division, and arrange all our flowering plants into one or other of these classes.*

Let us now carry this subdivision further, and notice that our Dicotyledons fall into three groups or divisions, according to the structure of their perianth. Thus, one section, including all the plants referred to in chaps. I., II., III., have their petals separate, and may be placed in one sub-class, called **Polypetalæ**; those referred to in chap. IV. have their petals united, and may therefore be placed in a second sub-class, **Gamopetalæ** ; while those referred to in chap. V. either have their corollas or their whole perianth wanting, and hence are placed in a third sub-class, called **Incompletæ**. We can further

* I purposely omit here Pines, Firs, and other coniferous plants, as I did in the preceding part of this book, as an examination of their structure could only be undertaken satisfactorily with appliances not usually to be found in schools.

subdivide these again. Thus, in sub-class Polypetalæ we may put into one subdivision all those plants (chaps. I. and III.), the flowers of which have their sepals, petals, stamens, and carpels separately attached to the receptacle or thalamus, and forming the division **Thalamifloræ**; into a second, those in which the petals and stamens are attached to a hypogynous disc, called **Discifloræ**; and into a third, those in which the petals and stamens are on the top of the ovary, or are attached to the calyx (chap. III.), called **Calycifloræ**. Sub-class Gamopetalæ divides into subdivisions **Epigynæ**, in which the corolla is, as its name implies, fastened above the ovary, and **Hypogynæ**, in which it is fastened under the ovary.

Similarly, in Monocotyledons two great divisions may be noticed: firstly, those which have a more or less distinct perianth, called (from the frequent resemblance of this to petals) **Petaloidæ**; and, secondly, those, like grasses and sedges, which have almost or altogether lost the perianth, and have its place and function taken by scale-like bracts or glumes, and which are therefore called **Glumiferæ**.

We may summarise this classification in a table thus:—

Class I. Dicotyledons.
- Sub-class I. Polypetalæ, petals free.
  - Division I. Thalamifloræ, calyx inferior, petals and stamens hypogynous.
  - Division II. Discifloræ, calyx inferior, petals and stamens on a hypogynous disc.
  - Division III. Calycifloræ, calyx inferior or superior, petals and stamens either perigynous or epigynous.
- Sub-class II. Gamopetalæ, petals joined.
  - Division I. Epigynæ, corolla epigynous.
  - Division II. Hypogynæ, corolla hypogynous.
- Sub-class III. Incompletæ, perianth consisting of sepals only, or wanting.

Class II. Monocotyledons.
- Sub-class I. Petaloidæ, with a more or less perfect perianth, which is often petaloid.
  - Division I. Epigynæ, perianth superior.
  - Division II. Hypogynæ, perianth inferior.
- Sub-class II. Glumiferæ, perianth imperfect or wanting, flowers placed in the axils of glumes.

These sub-classes or divisions are formed of smaller groups variously called *cohorts*, *tribes*, or *families*, and these again of *orders*. The orders are sometimes broken up into *sub-orders*, which in their turn consist of *genera*, and these are formed of one or more *species*.

It may here be pointed out that the sub-classes and their subdivisions are not always very natural, so that even in the best schemes of classification yet devised some more or less artificial groups are always to be met with. This is particularly the case with the Incompletæ, which has hitherto served as the waste-paper-basket of the systematic botanist. Whenever he came on a group of plants which, either by direct descent or by degeneration, have their organs in a condition of very imperfect development, he placed them in this sub-class, which thus has come to have no definite characters at all. Its members only agree in this, that they have either no corolla or no perianth at all; but these, as we know, are non-essential organs, readily liable to modification (*vide* pp. 75 and 110), and therefore, from a classificatory point of view, they ought to be treated as of little value. But until we know a great deal more about the relationships of plants than we do at present, something like the above classification must be generally adopted.

In any natural scheme of classification the most convenient starting-point is that assemblage of individuals which we call a *species*. But this is a term very difficult to define. It may be said to include all those forms "which have the most essential properties in common, are descended from one another, and produce fruitful descendants." In practice it is often very difficult to apply any rule for limiting the characters of species, and nearly every botanist who attempts to classify plants exercises his own judgment to a considerable extent. Thus, hardly any two botanists in or out of New Zealand could be got to agree as to the number of species of *Veronica* which grow wild in this colony, and the same remark applies to many other groups of plants—*e.g.*, *Epilobium*.

Next in importance to the species—indeed, in some respects of greater importance—comes the *genus*, which consists of a number of species agreeing in most points of structure, though they may differ a good deal in detail of external form, &c. But, while the definition of a genus is as vague as that of a species, and also depends to some extent on the ideas of individual botanists, yet there is on the whole greater unanimity as to generic limits than exists as to specific.

The reasons of this want of fixity in our definitions of these terms are not far to seek. We already know that all plants are liable to variation (though we need not inquire here into the causes of this), and that certain variations become more or less permanent, and we say that those individuals exhibiting such constitute a *variety;* but it is quite impossible to draw any hard-and-fast line between varieties and species, and to say that certain characteristics are only of *varietal* and others of *specific* importance. The modifications of struc-

ture which to-day make a variety may continue to diverge until in time they constitute a species, and specific characters in time come to be generic.

If, following the same idea, we try to look backwards instead of forward, we may say that the species which exist now—let us call it epoch A—were only varieties in the preceding epoch B; that the genera of to-day represented species in epoch B, and only varieties in epoch C; and that the orders of to-day were varieties perhaps as far back as epoch D or E. The outcome of such an idea is that a species is, after all, a unit of classification, possessing only a transient character; and, further—to come back to an idea already expressed—that if we could go far enough back in time we should find that all our existing plants were descended from a few (perhaps from one) primitive forms. The best (*i.e.*, the most natural) classification, therefore, is one which will enable us to group plants exactly by their descent relationships.

In the succeeding portion of this work it is only possible to state the characters of the more important Natural Orders, especial prominence being given to those characteristic of New Zealand. The arrangement followed among the Dicotyledons is not the best, which would probably be to place the Gamopetalæ first as the most highly-developed group, then the Polypetalæ, and lastly the Incompletæ; but, as the main systematic works dealing with New Zealand, Australian, and European botany (those of Hooker and Bentham) commence with the Polypetalæ, the same order has been followed here.

SYNOPSIS OF THE ORDERS OF INDIGENOUS AND INTRODUCED PLANTS OCCURRING IN NEW ZEALAND.*

Class I. DICOTYLEDONS.

Sub-class I. Polypetalæ.

Division I., Thalamifloræ.—Flowers with calyx and corolla; petals free, and inserted along with the stamens on the receptacle.

Exceptions.—Species without petals occur in Ranunculaceæ, Cruciferæ, and Caryophylleæ; with petals united at the base in Portulaceæ and Malvaceæ; with stamens perigynous in Caryophylleæ.

* *Pistil apocarpous. Embryo minute, in fleshy endosperm.*

1. Ranunculaceæ. — Herbs with alternate leaves, or opposite-leaved climbing shrubs. Flowers regular or irregular; stamens ∞. Fruit achenes or follicles. (P. 138.)

Several genera have petaloid sepals and no petals.

2. Magnoliaceæ, Sub-order Wintereæ.—Shrubs or trees with alternate leaves. Stamens ∞, with short thick filaments. Fruit succulent. (*Drimys* (Pepper-tree), 2 species.)

** *Pistil syncarpous, 1-celled, or 2- or more-celled by the prolongation of the placentæ; placentation parietal.*

Papaveraceæ. — Herbs with alternate leaves and milky juice. Sepals 2. Petals 4. Stamens ∞. Ovary 1-celled. Embryo minute, in fleshy endosperm. (*Papaver* (Poppy) and *Eschscholtzia.*)

Fumariaceæ. — Herbs, often climbing; leaves alternate, much divided. Flowers irregular; stamens 6, in 2 bundles. Ovary 1-celled. Embryo minute, in fleshy endosperm. (*Fumaria.*)

3. Cruciferæ.—Herbs with alternate exstipulate leaves. Sepals and petals 4. Stamens 6, tetradynamous. Ovary 2-celled by a membranous dissepiment. Seeds exalbuminous, with large embryo. (P. 138.)

4. Violaceæ.—Herbs or trees with alternate stipulate leaves. Flowers regular or irregular. Sepals, petals, and stamens 5; anthers with dilated connective. Seeds with large

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* Orders and genera of introduced plants are in small type.

straight embryo, in fleshy albumen. (*Viola* (Violet), 3 sp., 1 or 2 introduced species; *Melicytus* (Hina-hina), 4 sp.; *Hymenanthera*, 2 sp.)

5. PITTOSPOREÆ. — Shrubs or trees with alternate or whorled exstipulate leaves. Sepals, petals, and stamens 5; anthers oblong or sagittate. Ovary imperfectly 2–3-celled. Fruit a 2–3-valved woody capsule; seeds imbedded in a glutinous material; embryo minute, in hard albumen. (*Pittosporum* (Mapau), about 19 sp.)

*** *Pistil syncarpous, 1-celled; placentæ basal. Herbs with opposite entire leaves. Seeds with curved embryo in mealy endosperm.*

6. CARYOPHYLLEÆ.—Sepals and petals 4 or 5; stamens 4–5, or 8–10; styles 2–5; ovules numerous. (P. 139.)

7. PORTULACEÆ.—Sepals 2; petals 5, united at the base; stamens 5; style 1, 2–3-fid; ovules few. (*Claytonia*, 1 sp.; *Montia*, 1 sp.; *Hectorella*, 1 sp.)

8. PARONYCHIEÆ.—Sepals 4 (–5); petals 0; stamens 1 (–5), perigynous; style 1, 2-fid; ovule 1. (*Scleranthus*, 1 sp.)

**** *Pistil syncarpous, 2- or more-celled; placentæ axile.*

9. ELATINEÆ.—Small creeping water-herb, with opposite stipulate leaves. Flowers minute, solitary, and axillary. Sepals, petals, stamens, and stigmas 2 or 3. Seeds with little or no endosperm. (*Elatine*, 1 sp.)

10. HYPERICINEÆ.—Herbs (or shrubs); leaves opposite, exstipulate, often gland-dotted. Sepals and petals 5; stamens ∞; ovary 3–5-celled, or 1-celled with 3 produced placentæ. Capsule 3-valved; seeds albuminous. (*Hypericum* (St. John's Wort), 2 sp.; 1 or 2 introduced sp.)

11. MALVACEÆ.—Herbs, shrubs, or trees; leaves alternate, stipulate. Calyx 5-lobed, valvate; petals 5, contorted; stamens ∞, monadelphous, with 1-celled anthers. Ovary of 1 or more carpels, free or connate. Seeds with large folded cotyledons and little or no endosperm. (P. 139.)

12. TILIACEÆ.—Shrubs or trees; leaves alternate or opposite, stipulate or exstipulate. Sepals 4–5, valvate; petals 4–5, imbricate, often lobed or cut; stamens usually ∞, free, anthers 2-celled, often opening by pores. Ovary 2–6-celled; seeds albuminous. (*Entelea*, 1 sp.; *Aristotelia* (Mako-mako), 3 sp.; *Elæocarpus*, 2 sp.)

DIVISION II., DISCIFLORÆ.—Flowers with calyx and corolla; petals free, and inserted with the stamens on the surface or margin of a hypogynous disc.

Exceptions.—Petals united in Stackhousieæ, absent in some Rhamneæ and Sapindaceæ. Ovary inferior in some Rhamneæ.

13. LINEÆ.—Herbs with alternate entire leaves. Sepals 5. Petals 5, convolute in bud. Stamens 5; filaments united at the base. Disc 0. Ovary 3–5-celled, with as many styles; seeds albuminous. (*Linum* (Flax), 2 sp., 1 introduced sp.)

14. GERANIACEÆ.—Herbs, rarely shrubby; leaves various. Flowers regular or irregular. Sepals and petals 5. Torus scarcely expanded into a disc, sometimes 5-glandular. Stamens 10, some often imperfect. Ovary 5-celled, styles 5; seeds with little or 0 endosperm. (*Geranium* (Crane's Bill), 4 sp., introduced 1 or 2 sp.; *Pelargonium*, 1 sp.; *Oxalis* (Wood Sorrel), 2 sp.; *Erodium* (Stork's Bill), 1 sp.)

15. RUTACEÆ.—Shrubs or trees; leaves opposite or alternate, exstipulate. Sepals and petals 4–5. Stamens 8–10, free. Disc thick. Ovary 2–5-celled; styles lateral. Seeds albuminous. (*Phebalium*, 1 sp.; *Melicope*, 2 sp.)

16. MELIACEÆ.—Trees; leaves compound, exstipulate. Calyx small, 4–5-lobed, imbricate. Petals 4–5, valvate, united at the base to the staminal tube. Disc free. Stamens 8–10, monadelphous. Ovary 3–5-celled. Seeds exalbuminous. (*Dysoxylum*, 1 sp.)

17. OLACINEÆ.—(Shrubs or) trees; leaves alternate, exstipulate. Calyx minute, 5-toothed. Petals 5, valvate. Stamens 5. Ovary 1-celled; ovule 1. Seed with minute embryo in fleshy endosperm. (*Pennantia*, 1 sp.)

18. STACKHOUSIEÆ.—Minute herbs, with simple alternate leaves. Calyx 5-lobed. Petals 5, connate at the middle. Stamens 5. Ovary 3-lobed. Seeds with straight embryo in fleshy endosperm. (*Stackhousia*, 1 sp.)

19. RHAMNEÆ.—Shrubs or small trees; leaves opposite or alternate or 0, stipulate. Calyx 4–5-lobed, inferior, or adnate to the ovary. Petals 4–5, or 0. Stamens 4–5, inserted on the hypogynous or epigynous disc. Ovary inferior or superior, 3-celled, with 1 ovule in each cell. Seeds with large embryo and fleshy endosperm. (*Pomaderris*, 4 sp.; *Discaria*, 1 sp.)

20. SAPINDACEÆ, Sub-order DODONEÆ.—Shrubs or trees; leaves alternate, exstipulate, simple or pinnate. Sepals 3–5. Petals 0. Stamens 5–8. Ovary 1- or 2–3-celled. Seeds exalbuminous, with spirally-twisted cotyledons. (*Dodonæa*, 1 sp.; *Alectryon*, 1 sp.)

21. ANACARDIACEÆ.—Trees, with alternate exstipulate leaves. Calyx 5-lobed. Petals 5, perigynous. Stamens 5. Ovary 1-celled. Seed exalbuminous, with plano-convex cotyledons. (*Corynocarpus* (Karaka), 1 sp.)

Anomalous Order (or Genus).

22. CORIARIEÆ.—Herbs or shrubs; leaves opposite, simple, exstipulate. Sepals 5. Petals 5, becoming fleshy. Stamens 10. Ovary of 5 or 10 1-oveled separate carpels. Endosperm almost wanting. (*Coriaria* (Tutu), 3 sp.

DIVISION III., CALYCIFLORÆ. — Flowers with calyx and corolla. Petals free, and inserted with the stamens on the calyx or on an epigynous disc.

Exceptions.—Petals and stamens hypogynous in some Droseraceæ. Petals absent in some Halorageæ, Onagrarieæ, Ficoideæ, and Araliaceæ.

* *Calyx inferior (except in some Rosaceæ and Saxifrageæ). Stamens perigynous (rarely hypogynous).*

† *Seeds exalbuminous.*

23. LEGUMINOSÆ. — Leaves usually alternate, compound and stipulate. Calyx (4–)5-lobed. Petals (4–)5. Stamens 10 (or ∞), usually more or less connate. Ovary of one 1-celled carpel. (See p. 140.)

24. ROSACEÆ.—Leaves alternate, simple or compound, stipulate. Calyx inferior, or tube adnate to the ovary, 4–5-lobed. Petals 4–5. Stamens ∞ (rarely 1–5) free, curved inwards in bud. Ovary of 1 or more carpels, free or connate. (P. 141.)

†† *Seeds with fleshy endosperm.*

25. SAXIFRAGEÆ.—(Herbs), shrubs, or trees. Calyx inferior, or tube adnate to the ovary, 4–5-lobed. Petals 4–5. Stamens 5, or 8–10, free. Ovary 2–5-celled. (*Quintinia*, 2 sp.; *Ixerba*, 1 sp.; *Carpodetus*, 1 sp.; *Ackama*, 1 sp.; *Weinmannia*, 2 sp.)

26. CRASSULACEÆ.—Herbs, usually succulent, with entire opposite leaves. Sepals, petals, stamens, and carpels 3–5. Pistil apocarpous. (*Tillæa*, 5 sp.)

27. DROSERACEÆ. — Glandular herbs with alternate or radical leaves. Sepals and petals 5, imbricate. Stamens 5 Ovary 1-celled, with ∞ ovules on a parietal placenta. (*Drosera* (Sundew), 6 sp.)

** *Calyx-limb adnate to the ovary. Stamens epigynous.*

a. One ovule in each cell. Seeds albuminous.

28. HALORAGEÆ.—Herbs, often marsh or aquatic; leaves radical, opposite or whorled. Flowers minute, usually unisexual. Calyx-limb 4-toothed, or 0. Petals 2, 4, or 0. Stamens 1, 2, or 4. Ovary 1-, 2-, or 4-celled; ovules pendulous. (*Haloragis*, 6 sp.; *Myriophyllum*, 4 sp.; *Gunnera*, 3 sp.; *Callitriche*, 1 sp.)

β. Ovules numerous on axile placentæ. Endosperm 0.

29. MYRTACEÆ.—Trees or shrubs; leaves opposite, with pellucid dots. Calyx-lobes 4–5, valvate or imbricate. Petals 4–5. Stamens ∞, free. (P. 141.)

30. Onagrarieæ.—Herbs, shrubs, or trees; leaves opposite or alternate. Calyx-lobes 4, valvate. Petals 4, contorted (0 in *Fuchsia kirkii*). Stamens 8. (*Fuchsia*, 4 sp.; *Epilobium*, about 17 sp.) (P. 142.)

γ. Ovules few or ∞, on parietal placentæ. Endosperm 0.

31. Passifloreæ. — Climbing shrub; leaves alternate, tendril-bearing. Calyx 4–5-lobed. Petals 4–5, with a corona. Stamens 4–5. Fruit a berry with ∞ seeds. (*Passiflora* (Passion-flower), 1 sp.)

32. Cucurbitaceæ. — Climbing herb; leaves alternate, tendril-bearing. Flowers unisexual. Calyx 5-toothed. Petals 5, connate. Stamens 3 (–5), united into a column. Fruit a 1-celled spinous nut, with 1 seed. (*Sicyos*, 1 sp.)

δ. Ovules few or ∞, on axile placentæ. Endosperm fleshy.

33. Ficoideæ.—Fleshy herbs. Calyx 3–5-lobed. Petals ∞ or 0. Stamens 3–8 or ∞. Ovary 3–8-celled. Fruit a capsule (enclosed in the fleshy calyx-tube) or indehiscent. (*Mesembryanthemum*, 1 sp.; *Tetragonia*, 1 sp.)

ε. Ovules solitary in each cell. Endosperm horny or fleshy.

34. Umbelliferæ.—Herbs, rarely undershrubs. Flowers umbellate. Petals and stamens 5. Styles 2. Fruit separating into 2 dry nuts. (P. 143.)

35. Araliaceæ.—Shrubs or trees, rarely herbs. Flowers umbellate. Petals 5 (0 in *Meryta*). Stamens 5. Styles 2–10. Fruit fleshy or coriaceous, 2–10-celled. (*Stilbocarpa*, 1 sp.; *Aralia*, 1 sp.; *Panax*, 11 sp.; *Schefflera*, 1 sp.; *Meryta*, 1 sp.)

36. Corneæ. — Shrubs or trees. Flowers solitary or panicled. Petals and stamens 5. Styles 2–3, or 0. Ovary 1–2-celled. Fruit a berry or drupe. (*Griselinia* (Broadleaf), 2 sp.; *Corokia*, 2 sp.)

Sub-class II. Gamopetalæ or Corollifloræ.—Petals joined.

Exceptions.—Corolla wanting in some Oleineæ. Petals free in some Myrsineæ.

Division I., Epigynæ.—Flowers with calyx and corolla, the latter epigynous.

* *Stamens epipetalous.*

37. Caprifoliaceæ.—Shrubs or trees; leaves alternate (or opposite), exstipulate. Flowers solitary or panicled (often irregular). Anthers free. Ovary 2-celled, with several ovules in each cell. (*Alseuosmia*, 4 sp.)

38. Rubiaceæ.—Shrubs or trees with opposite stipulate leaves, or herbs with whorled and (apparently) exstipulate leaves. Flowers solitary or panicled. Anthers free. Ovary 2-celled, with 1 ovule in each cell. (P. 143.)

39. Compositæ.—Trees, shrubs, or herbs, with alternate or radical exstipulate leaves. Flowers (florets) small, crowded into involucrate heads. Anthers syngenesious. Ovary 1-celled, with 1 erect ovule. (P. 144.)

** *Stamens epigynous.*

40. Stylidieæ. — Small herbs. Stamens 2; filaments united with the style into a column; anthers usually transverse. Ovary 1- or 2-celled, with numerous ovules. (*Forstera*, 3 sp.; *Phyllachne*, 5 sp.; *Oreostylidium*, 1 sp.; *Donatia*, 1 sp.)

41. Goodeniaceæ.—Herbs. Corolla 1–2-lipped, split posteriorly to the base. Anthers 5, free. Ovary 2-celled; ovules 1, or numerous in each cell. (*Selliera*, 1 sp.; *Scævola*, 1 sp. in Kermadec Islands only.)

42. Campanulaceæ.—Herbs, often with milky juice. Corolla regular, campanulate. Anthers 5, free. Ovary 2–5-celled; ovules numerous. (*Wahlenbergia*, 3 sp.)

43. Lobeliaceæ.—Herbs with milky juice. Corolla 1–2-lipped, posteriorly split to the base. Anthers 5, united. Ovary 2-celled; ovules numerous. (*Lobelia*, 2 sp.; *Colensoa*, 1 sp.; *Pratia*, 4 sp.)

Division II., Hypogynæ.—Flowers with calyx and corolla, the latter hypogynous.

Exceptions.—Ovary inferior in some Ericaceæ and Primulaceæ.

* *Flowers usually regular.*

a. Stamens as many as and opposite the corolla-lobes, or twice their number.

44. Ericaceæ (including Epacrideæ).—Shrubs or small trees. Stamens hypogynous with 2-celled anthers opening by pores, or epipetalous with 1-celled anthers. (P. 145.)

45. Myrsineæ. — Shrubs or small trees; leaves gland-dotted. Corolla of 4 or 5 nearly free petals. Ovary 1-celled, with 1 or more ovules on or in a free-central, often fleshy globose placenta. Fruit a 1-seeded berry. (*Myrsine*, 6 sp.)

46. Primulaceæ.—Herbs. Ovary 1-celled, with numerous ovules on a free-central placenta. Fruit a 5–10-valved capsule, or dehiscing transversely. (*Samolus*, 1 sp.; *Anagallis*, 1 introduced species.)

47. Sapoteæ.—Shrubs or trees with milky juice; leaves entire. Corolla 4–6-lobed. Ovary 4- or more-celled, with 1 ovule in each cell. Fruit a 1-seeded berry. (*Sideroxylon*, 1 sp.)

β. Stamens as many as and alternate with corolla-lobes.

† *Leaves opposite.*

48. OLEINEÆ.—Shrubs or trees. Corolla absent (in the New Zealand genus). Stamens 2. Ovary 2-celled. Fruit a 1- or 2-celled drupe. (*Olea*, 3 sp.)

49. APOCYNEÆ.—Climbing shrubs. Stamens 5, with sagittate anthers adhering to the stigma. Ovary 2-celled. Fruit of two long follicles. Seeds with a tuft of silky hairs. (*Parsonsia*, 2 sp.)

50. LOGANIACEÆ.—Shrubs or herbs. Stamens 4 or 5, anthers free. Ovary 2-celled. Fruit a 2-valved many-seeded capsule. (*Mitrasacme*, 1 sp.; *Logania*, 3 sp.; *Geniostoma*, 1 sp.)

51. GENTIANEÆ.—Herbs with bitter juice. Stamens 4 or 5, anthers free. Ovary 1-celled, with 2 parietal placentæ. Fruit a 2-valved capsule. (*Gentiana*, 4 sp.; *Sebæa*, 1 sp.; *Liparophyllum*, 1 sp.; *Erythræa*, 1 introduced species.)

†† *Leaves alternate, exstipulate.*

52. BORAGINEÆ. — Herbs, frequently hispid, with entire leaves and scorpioid inflorescence. Corolla imbricate. Ovary 4-lobed to the base, consisting of 2 carpels, each 2-lobed and 2-celled, and containing a single ovule in each cell. Style 1, gynobasic. Fruit of 4 nucules. (P. 146.)

53. CONVOLVULACEÆ.—Climbing or prostrate herbs (*Cuscuta* is a leafless parasite). Corolla plaited or imbricate. Ovary 2- (rarely 3-) celled, with 1 or 2 ovules in each cell. Fruit a 1–2-celled capsule, sometimes indehiscent. (*Convolvulus*, 1 sp.; *Calystegia*, 4 sp.; *Ipomœa*, 1 sp.; *Dichondra*, 1 sp.; *Cuscuta*, 1 sp., 2 or 3 introduced species.)

54. SOLANEÆ.—Herbs, often shrubby. Corolla plaited. Stamens with anthers often cohering and opening by terminal pores. Ovary 2-celled, with numerous ovules. Fruit a berry. (*Solanum* (Potato, Poro-poro, &c.), 2 sp.)

55. PLANTAGINEÆ. — Scapigerous, acaulescent herbs; leaves radical. Corolla scarious, 4-lobed. Stamens 4; anthers pendulous. Ovary 2-celled. Capsule dehiscing transversely. (*Plantago*, 7 sp.; 2 or 3 introduced.)

** *Flowers usually irregular and 2-lipped.*

56. SCROPHULARINEÆ.—Herbs or opposite-leaved shrubs. Stamens 2, or 4 and didynamous. Ovary 2-celled, with numerous ovules on axile placentæ. Fruit a capsule. (P. 146.)

57. GESNERACEÆ.—Opposite-leaved shrub. Stamens 4, didynamous, with a rudimentary fifth. Ovary 1-celled, with numerous ovules on 2 produced parietal placentæ. Fruit a capsule. (*Rhabdothamnus*, 1 sp.)

58. Lentibularieæ.—Small aquatic herbs; stems furnished with minute bladders. Stamens 2, with 1-celled anthers. Ovary 1-celled, with numerous ovules on a free-central placenta. (*Utricularia*, 4 sp.)

59. Myoporineæ.—Tree, with alternate gland-dotted leaves. Corolla nearly regular. Stamens 4, sub-equal. Ovary 2–4-celled, with 1 (or 2) ovules in each cell. Fruit a drupe. (*Myoporum* (Ngaio), 1 sp.)

60. Verbenaceæ.—Herbs, shrubs, or trees, with opposite leaves. Corolla 2-lipped or regular. Stamens 4; anthers 1- or 2-celled. Ovary 2–4-celled, with 1 or 2 pendulous ovules in each cell. Fruit a drupe, or of 4 nuts, or indehiscent. (*Vitex* (Puriri), 1 sp.; *Teucridium*, 1 sp.; *Avicennia*, 1 sp.)

61. Labiatæ.—Square-stemmed herbs, usually aromatic. Stamens 4, equal or didynamous. Ovary deeply 4-lobed, consisting of 2 2-lobed and 2-celled carpels containing 1 ovule in each cell. Fruit of 4 nucules. (*Mentha*, 1 sp., 1 or 2 introduced sp. of Mint; *Scutellaria*, 1 sp.; *Prunella* (Self-heal), introduced, 1 sp.)

Sub-class III. Incompletæ.

Division I., Monochlamydeæ.—Perianth present.

a. Ovary superior; fruit often enclosed in the perianth.

† *Ovary 1-celled, 1-ovuled, usually with two or more styles. Endosperm mealy.*

62. Nyctagineæ.—Tree; leaves opposite, entire. Perianth 5-lobed, becoming viscid in fruit. Stamens 6–8, hypogynous. Style only 1. Embryo with foliaceous cotyledons folded round the endosperm. (*Pisonia*, 1 sp.)

63. Polygoneæ.—Herbs or shrubs; leaves alternate, stipules ochreate. Perianth 5–6-partite. Stamens 6–8, perigynous. Styles (2 or) 3. Ovule basal. Fruit a nut; seed with straight embryo. (P. 147.)

64. Amaranthaceæ.—Herb; leaves opposite. Perianth 5-partite. Stamens 5 (2 often imperfect), hypogynous; anthers 1-celled. Style short; stigma 2-fid. Ovule basal. Fruit an utricle; seed with curved embryo. (*Alternanthera*, 1 sp.)

65. Chenopodiaceæ.—Herbs, with alternate leaves or 0. Perianth 3–5-partite, or utricular. Stamens 1–5, perigynous. Styles 2–5. Ovule basal. Fruit a nut; seed with curved embryo surrounding the endosperm. (*Chenopodium*, 7 sp.; *Atriplex*, 3 sp.; *Suæda*, 1 sp.; *Arthrocnemum*, 1 sp.; *Salsola*, 1 sp.; *Salicornia*, 1 sp.)

†† *Ovary 1-celled, with 1 or 2 (rarely more) ovules; style 1; embryo small, endosperm fleshy or none.*

66. Monimiaceæ.—Trees, with opposite leaves. Perianth 5–10-lobed. Stamens 6–10 or ∞; anthers opening by slits or

valves. Ovule erect or pendulous. Fruit of drupes or achenes; seeds with fleshy endosperm. (*Laurelia*, 1 sp.; *Hedycarya*, 1 sp.)

67. Laurineæ.—Trees with alternate leaves, or twining parasitic leafless herb. Perianth 4–8-partite. Stamens about 12; anthers 2–4-celled, opening by recurved valves. Ovule pendulous. Fruit a drupe or berry; seed exalbuminous. (*Litsæa*, 1 sp.; *Beilschmeidia*, 2 sp.; *Cassytha*, 1 sp.)

68. Proteaceæ.—Trees. Perianth 4-partite or of 4 leaves. Stamens 4; anthers nearly sessile on the perianth-segments. Fruit a drupe or follicle; seeds exalbuminous. (*Knightia*, 1 sp.; *Persoonia*, 1 sp.)

69. Thymeleæ.—Shrubs, with tough bark. Perianth 4-lobed. Stamens 2 or 4, on the perianth-tube. Ovule pendulous. Fruit a nut; seed with little endosperm or 0. (*Pimelea*, 11 sp.; *Drapetes*, 3 sp.)

70. Urticeæ (including Moreæ).—Herbs, rarely trees, with milky juice. Perianth 2–4-lobed or -partite. Stamens as many as its lobes. Style short or 0. Fruit a nut or drupe; seed with little or no endosperm. (*Paratrophis*, 1 sp.; *Urtica* (Nettle), 4 sp., 1 introduced sp.; *Elatostemma*, 1 sp.; *Parietaria*, 1 sp.; *Australina*, 1 sp.)

β. Ovary usually inferior.

71. Santalaceæ.—Shrubs or trees. Perianth 4–6-lobed. Stamens 4–6. Ovary 1-celled, with central placenta; ovules 3–5, pendulous. Fruit a nut or drupe; seed 1, with small embryo in fleshy endosperm. (*Exocarpus*, 1 sp.; *Fusanus*, 1 sp.)

72. Loranthaceæ.—Shrubs, parasitic on trees; leaves sometimes 0. Perianth 4–5-partite, or of 4 or 5 leaves. Stamens 4–5, inserted on the perianth-segments. Ovary 1-celled, with 1 ovule. Fruit a berry; seed albuminous. (*Loranthus*, 7 sp.; *Viscum*, 2 sp.; *Tupeia*, 1 sp. All are known as Mistletoes.)

Division II., Achlamydeæ.—Perianth usually wanting (present in *Poranthera*).

73. Euphorbiaceæ.—Herbs, with milky juice. Flowers monœcious: either in a cup-shaped involucre without a perianth; or with a distinct 5-lobed calyx, 5 white petals, and 5 stamens. Fruit a 3-partite schizocarp; seeds with straight embryo in fleshy endosperm. (*Poranthera*, 1 sp.; *Euphorbia* (Spurge), 1 sp., and 4 or 5 introduced species.)

Salicineæ.—Trees or shrubs, with simple, alternate, stipulate leaves. Flowers diœcious, in catkins; ♂ of 1 or more stamens, inserted under the disk, with free or connate filaments; ♀ of 1 1-celled ovary, with 2 styles, and numerous ovules on 2 parietal placentæ. Fruit a

1-celled loculicidal capsule; seeds with a tuft of silky hairs, exalbuminous. (*Populus* (Poplar) and *Salix* (Willow); several introduced species of each.)

74. CUPULIFERÆ.—Trees, with alternate stipulate leaves. Flowers monœcious: ♂ consisting of 8–12 stamens in a 5–6-lobed involucre; ♀ of 2 or 4 3-celled ovaries in a 4-lobed involucre. Ovules 1 in each cell. Fruit of winged nuts; seeds exalbuminous. (*Fagus* (Beech or Birch trees), 4 sp.)

75. PIPERACEÆ. — Herbs or shrubs, often aromatic. Flowers very minute, crowded on a scaly spadix. Stamens 2. Ovary 1-celled; stigma entire or 2–5-lobed; ovule 1, erect. Fruit a berry; seed albuminous, with a minute embryo at its upper end. (*Piper*, 1 sp.; *Peperomia*, 1 sp.)

76. CHLORANTHACEÆ.—Glabrous shrub. Flowers in bracteate spikes, diœcious: ♂ of 1 stamen; ♀ of a sessile 1-celled ovary with 1 pendulous ovule. Fruit a drupe; seed with minute embryo in fleshy endosperm. (*Ascarina*, 1 sp.)

77. BALANOPHOREÆ. — A leafless root-parasite. Flowers minute, diœcious, on crowded spadices: ♂ of a solitary sessile 2-celled anther; ♀ of a 1-celled ovary, with adnate 2–3-lobed perianth, enclosing 1 pendulous ovule. Fruit? (*Dactylanthus*, 1 sp.)

(Though not belonging to this group of flowering plants, the following order is introduced here, as most systematists place it for convenience at the end of the Dicotyledons.)

CONIFERÆ.—Shrubs or trees. Flowers monœcious or diœcious: ♂ inflorescence consisting of catkins; anther-cells 2, 4, or 8–16, attached to a scale; ♀ of one or more naked ovules, without ovary, style, or stigma, attached to scales which are collected into woody cones or catkins, or are nearly solitary. Seeds nut- or drupe-like, with straight embryo in fleshy endosperm; cotyledons 2 or more. (*Dammara* (Kauri), 1 sp.; *Libocedrus* (Cedars), 2 sp.; *Podocarpus* (Miro, Black- and White-pines, Totara, &c.), 5 sp.; *Dacrydium* (Red- and Yellow-pines), 7 sp.; *Phyllocladus* (Bog-pine), 3 sp.)

CLASS II. MONOCOTYLEDONS.

Sub-class I. PETALOIDEÆ.

DIVISION I., EPIGYNÆ.—Perianth superior, 6-leaved.

1. ORCHIDEÆ. — Epiphytic shrubs or terrestrial herbs. Flowers very irregular. Stamens 1, united with the style. Ovary 1-celled, with 3 parietal placentæ. (P. 147.)

2. IRIDEÆ.—Herbs, with linear laterally-flattened leaves. Perianth regular. Stamens 3, anthers extrorse. Capsule loculicidally 3-valved. (*Libertia*, 3 sp.)

3. HYPOXIDEÆ.—Small herbs, with radical leaves. Perianth regular. Stamens 6; anthers introrse. Capsule 3-celled, dehiscing longitudinally. (*Hypoxis*, 1 sp.)

Division II., Hypogynæ. — Perianth inferior and 6-leaved or 0.

Series I., Coronarieæ.—*Perianth 2-seriate. Ovary syncarpous.*

4. Liliaceæ.—Herbs, climbing shrubs, or trees. Perianth of 6 similar-coloured segments or leaves. Stamens 6, anthers introrse, versatile. Ovary 3- (rarely 1-) celled; style simple, stigma 3-lobed. Ovules 2 or more (rarely 1) in each cell. Fruit a capsule or berry; seeds with terete embryo in horny endosperm. (P. 148.)

5. Juncaceæ.—Grassy or rush-like herbs, often leafless. Perianth of 6 dry, chaffy segments. Stamens 6 (or 3). Ovary 3-angled, 1–3-celled; ovules 1 or ∞. Capsule included in the persistent perianth, loculicidally 3-valved. Seeds minute, albuminous, with minute embryo. (*Juncus* (Rushes), 15 sp.; *Rostkovia*, 2 sp.; *Luzula* (Wood-rushes), 5 sp.)

6. Palmeæ. — Stem arboreous; leaves large, pinnate. Flowers panicled, enclosed when young in spathes. Perianth of 6 fleshy leaves. Stamens 6; anthers versatile. Ovary 3-celled, with 1 ovule in each cell. Fruit a drupe; seed with small embryo in horny endosperm. (*Areca* (Nikau Palm), 1 sp.)

Series II., Nudifloræ. — *Perianth of small scales or 0. Ovary apocarpous.*

7. Pandaneæ.—Climbing shrubs. Flowers closely packed into dense spathaceous spikes, diœcious; perianth 0; stamens in bundles, anthers 2-celled; ovaries crowded, 1-celled, with sessile stigma and numerous ovules on parietal placentæ. Fruit semi-succulent; seeds with minute embryo in fleshy endosperm. (*Freycinetia* (Kiekie), 1 sp.)

8. Typhaceæ. — Tall aquatic herbs, with linear leaves. Flowers in dense spikes or heads, the upper one or more ♂, the lower one or more ♀. Stamens crowded, anthers basifixed. Ovaries densely crowded, 1-celled, with slender style and stigma; ovule solitary, pendulous. Fruit a nut; seed with straight embryo in mealy endosperm. (*Typha* (Bullrush), 1 sp.; *Sparganium* (Bur-reed), 1 sp.)

9. Lemnaceæ. — Minute green floating scale-like fronds, without stems or leaves; flowers (very rarely produced) on the margins of the fronds, consisting of a bract enclosing 1 or 2 stamens, and a single 1-celled ovary. (*Lemna* (Duck-weed), 2 sp.)

10. Naiadeæ.—Submerged or erect fresh- or salt-water herbs; leaves floating, or grass-like, or filiform. Flowers spiked or solitary, sometimes enclosed in a leaf-like spathe, ☿ or unisexual; perianth of 4–6 small leaves or 0; stamens 1, 4, or 6, anthers sessile; ovary of 6 or fewer carpels, with a

solitary pendulous ovule in each carpel. Fruit of nuts or drupes; seeds with a straight or curved embryo, large radicle, and no endosperm. (*Triglochin*, 1 sp.; *Potamogeton* (Pond-weed), 4 sp.; *Ruppia*, 1 sp.; *Zannichellia*, 1 sp.; *Zostera* (Sea-wrack), 2 sp.)

Sub-class II. GLUMACEÆ.

11. RESTIACEÆ.—Grass- or rush-like plants; leaf-sheaths split to the base. Flowers unisexual. Perianth 0 or of 6 leaflets. Stamens 3 (sometimes 1 or 2); anthers 1-celled, versatile. Ovary 1-celled, with 2 or 3 stigmas, or of 2–18 free carpels; ovule solitary and pendulous in each cell. Fruit a nut, or a 1- or more-celled capsule; seed with small embryo at the base of mealy endosperm. (*Leptocarpus*, 1 sp.; *Hypolæna*, 1 sp.; *Gaimardia*, 3 sp.; *Sporadanthus*, 1 sp.)

12. CYPERACEÆ.—Grass- or rush-like plants; culms solid; leaf-sheaths entire. Perianth 0, or of bristles or scales. Stamens 1–6; anthers 2-celled, basifixed. Ovary 1-celled; style 1; stigmas 1–3, filiform; ovule erect. Seed with embryo in the base of floury endosperm. (P. 149.)

13. GRAMINEÆ.—Grasses; culms hollow, jointed; leaf-sheaths split to the base. Perianth 0, or of 2 minute scales. Stamens 3; anthers 2-celled, versatile. Ovary 1-celled; stigmas 2, feathery; ovule erect. Seed with embryo at one side of the base of floury endosperm. (P. 150.)

DETAILED CHARACTERS OF IMPORTANT NEW ZEALAND ORDERS.

DICOTYLEDONS.

Order I. Ranunculaceæ.

Herbs with alternate or radical leaves, or climbing shrubs with opposite leaves. Flowers regular or irregular. Sepals 3–8 or more, often petaloid, usually deciduous. Petals 5–20, or wanting, sometimes reduced to nectaries. Stamens ∞, free; anthers adnate, dehiscing by lateral slits. Carpels ∞, usually free and 1-celled; ovules 1 or more on the ventral suture, anatropous. Fruit of 1-seeded achenes or many-seeded follicles; seeds small, with copious endosperm and a minute embryo. (Pp. 3–15, figs. 1–8.)

The order is a somewhat large one in temperate and cold regions, but rare in the tropics, and includes about 30 genera and 500 species. Of this number 4 genera are represented by 35 species in New Zealand. Of these, *Clematis* (6 sp.) and *Caltha* (1 sp.) are Australian in affinity: *Myosurus aristatus* is found also in America. Of the 27 species of *Ranunculus*, the most are endemic. A few introduced species of the latter genus have gone wild in many parts of the colony.

Many of the genera are cultivated for their flowers—*e.g.*, *Clematis*, *Anemone*, *Adonis*, *Ranunculus* (the New Zealand *R. lyallii* being the finest species known), *Helleborus* (Christmas Rose), *Eranthis* (Winter Aconite), *Nigella* (Love in a Mist), *Aquilegia* (Columbine), *Delphinium* (Larkspur), *Aconitum* (Monkshood), and *Pæonia* (Pæony Rose). Many of these, as their trivial names imply, have irregular flowers.

Most plants of the order are acrid, and some are poisonous. From their powerful properties, many, such as Aconite, are most valuable as medicines.

Order III. Cruciferæ.

Herbs, with radical or alternate exstipulate leaves. Flowers racemed. Sepals 4, 2 often saccate at the base. Petals 4, placed crosswise, imbricate. Stamens 6, tetradynamous, sometimes reduced to 4, 2, or 1. Ovary 2-celled by a false dissepiment (replum); stigma simple or 2-lobed; ovules 2 or more on two parietal placentæ. Fruit a siliqua or silicula, opening by 2 valves, rarely indehiscent, or dehiscing transversely; seeds exalbuminous, with large cotyledons, the radicle facing the edges of the cotyledons (*accumbent*), or lying on the back of one of them (*incumbent*). (Pp. 16–19, figs. 9–15.)

The order is a large one, particularly in temperate and cold regions, but rare in the tropics, and includes over 170 genera and 1,200 species. Of these, 7 genera, represented by 18 species, occur in New Zealand. Some species are ubiquitous, but the majority are endemic, *Pachycladon* (1 sp.) and *Notothlaspi* (2 sp.) being confined to these islands. Many introduced species have run wild.

Most of the species contain sulphur and a considerable quantity of nitrogenous substances, and to these they owe their nutritive, stimulating, and often pungent properties. They are therefore said to be *anti-scorbutic*. The following are cultivated as vegetables: Cabbage and its varieties (Savoy, Cauliflower, Brocoli, &c.), Turnip, Radish, Cress, Mustard, Sea-kale, Horse-radish, &c. The seeds of many species yield oil, the Rape (from which colza-oil is obtained) being chiefly cultivated for this purpose. Many genera are cultivated for their flowers—*e.g.*, *Matthiola* (Stock), *Cheiranthus* (Wallflower), *Arabis*, *Lunaria* (Honesty), *Alyssum*, Candytuft, &c.

Order VI. Caryophylleæ.

Herbs, with opposite entire leaves springing from tumid nodes; stipules 0, or, when present, very small and scarious. Inflorescence cymose. Sepals 4 or 5, free or united, imbricate. Petals 4 or 5, sometimes 0, hypogynous or perigynous. Stamens 8 or 10, sometimes fewer, inserted with the petals. Ovary 1-celled, or 3–5-celled in its lower portion; styles 2–5; ovules ∞, on slender basal funicles which are sometimes joined into a free-central placenta. Fruit a capsule, dehiscing by as many or twice as many teeth (valves) as there are styles; seeds with floury endosperm, and usually a cylindrical curved embryo. (Pp. 22–26, figs. 21–28.)

The order is a large one, particularly in the north temperate and arctic regions, and includes some 35 genera and 800 species. 4 genera and 12 species are in New Zealand: of these *Spergularia rubra* and *Gypsophila tubulosa* are of wide distribution, while *Stellaria*, though widely spread in the Northern Hemisphere, is represented here by 5 endemic species of Tasmanian affinities. *Colobanthus* (5 sp.) is an antarctic genus.

None of the species are of economic importance, but some of its genera (of the tribe Sileneæ) are cultivated for their flowers—*e.g.*, *Dianthus* (Pinks, Carnations, and Sweet Williams), *Agrostemma*, *Silene*, *Lychnis*, *Viscaria*, and *Saponaria*.

Order X. Malvaceæ.

Herbs, shrubs, or trees, with stellate hairs; leaves alternate, stipulate. Flowers often handsome, with or without bracts. Calyx 5-lobed, valvate. Petals 5, adnate at the base to the tube of the stamens, twisted in bud. Stamens ∞, monadelphous; anthers usually reniform and 1-celled. Disc 0, or produced up between the carpels. Carpels 1 or more, free or united, whorled round and adnate with the torus; styles as many as the carpels, connate below. Fruit of 1 or more dry indehiscent schizocarps, or capsular; seeds often woolly, with large folded cotyledons and little or no endosperm.

A large order, of wide distribution, including about 60 genera and 700 species. Of these, only 3 genera, represented by 6 species—viz., *Plagianthus* (Ribbon-wood) 3 sp., *Hoheria*, 2 sp., and *Hibiscus*, 1 sp.—occur in New Zealand. The latter is an ubiquitous species; all the rest are endemic, but of Australian affinities. Two or three introduced species of *Malva* have become wild. The plants of the order are mostly mucilaginous, and many are of great value. Cotton consists of the hairs covering the seeds of the genus *Gossypium*. The Baobab (*Adansonia*), of tropical Africa, is one of the stoutest trees known. *Durio* yields the Jack-fruit, or Durian, of fine flavour, but repulsive smell. The following genera are cultivated for their flowers: *Althæa* (Hollyhock), *Malva* (Mallow), *Lavatera* (Tree-mallow), *Malope*, *Abutilon*, and *Hibiscus*. (Pp. 26–28, figs. 29–31.)

Order XXIII. Leguminosæ.

Herbs, shrubs, or trees, with alternate, compound, usually stipulate leaves. All the plants of the order agree in having a pistil formed of 1 carpel, ripening into a legume or remaining indehiscent; seed exalbuminous.

Sub-order I. Papilionaceæ.

Herbs, shrubs, or trees. Calyx 5-toothed, often 2-lipped. Petals 5, almost hypogynous, unequal; the upper or *standard* enclosing the others in bud; the two lateral or *wings* usually enclosing the two inner, which often cohere to form the *keel*. Stamens 10, almost hypogynous, monadelphous, or 9 united and 1 free, very rarely all free. Ovary tapering into a straight or curved style, with a small simple lateral or capitate stigma. Fruit a 1- or more-seeded legume, or indehiscent. Embryo with plano-convex cotyledons and short incurved radicle. (Pp. 36–40, figs. 40–51.)

Sub-order II. Cæsalpineæ.

Shrubs or trees. Calyx 5-toothed. Corolla usually of 5 regular or irregular petals. Stamens 10 or fewer, all free. Embryo straight, with or without endosperm.

Sub-order III. Mimoseæ.

Shrubs or trees; leaves often replaced by phyllodes. Calyx 4–5-fid, valvate. Petals as many as the sepals, free or united. Stamens twice as many as the petals or ∞, free or monadelphous. (P. 41, fig. 52.)

An immense order, including about 400 genera and 6,500 species. Cæsalpinieæ, with 76 genera and 650 species, occur chiefly in the tropics; Mimoseæ, with 28 genera and about 1,150 species, more particularly in Australia and Africa; while Papilionaceæ are widespread in their distribution.

In no other country are there so few representatives of this great order as in New Zealand, there being altogether only 14 species, referable to 5 genera, in the islands, all belonging to Papilionaceæ. Of these, *Carmichælia* is a peculiar endemic genus of 10 species, the affinities of which are not very apparent. The other four genera are each represented by a single species. *Notospartium* is also quite peculiar and endemic, differing from all the known genera. *Swainsonia* is a large Australian

genus, but our species is endemic. *Clianthus* is a genus of two species only, the other being an Australian plant. *Sophora* (Kowhai) is a large tropical genus, and the local species occurs also in Juan Fernandez and South America.

Many introduced plants of the order are now found in the wild state, as Furze, Gorse, or Whin (*Ulex*), Broom (*Cytisus*), Clovers (*Trifolium*), Tares (*Vicia*), &c.

The order abounds in food- and forage-plants and in useful products. Only the more familiar can be mentioned here. Of food-plants may be named Pea (*Pisum*), Bean (*Faba*), Kidney, French or Haricot Bean (*Phaseolus*), and Lentil (*Ervum*). Clovers, Lucerne (*Medicago*), Sainfoin (*Onobrychis*), Vetch (*Vicia*), and Lupins are useful for fodder. Other products of the order are Gum Arabic, Gum Tragacanth, Catechu, Balsam of Copaiba, Balsam of Tolu, Copal-resin, Senna, Carob or Locust Beans, Liquorice, Tamarinds, Indigo, Logwood, Brazil-wood, Sunn Hemp, Wattle-bark, &c.

Many leguminous plants, as *Dolichos*, Lupins, Sweet-peas (*Lathyrus*), *Wistaria*, Laburnum (*Cytisus*), &c., are cultivated for their flowers.

Order XXIV. Rosaceæ.

Herbs, shrubs, or trees, with simple or compound alternate stipulate leaves. Flowers regular. Calyx 4–5-lobed, inferior, or tube produced and enclosing the carpels. Petals usually 5 (or 4), inserted on the calyx or under the margin of the disc, imbricate. Stamens ∞, rarely 1–5, free, incurved in bud, inserted with the petals or on the disc. Disc lining the calyx-tube. Carpels 1 or more, free, or connate and enclosed in the calyx-tube; styles as many as the carpels, often lateral or basal; ovules 1 or 2 in each carpel, anatropous. Fruit of one or more achenes or drupels (or a drupe or pome). Seeds exalbuminous; embryo with plano-convex cotyledons and short radicle. (Pp. 41–45, figs. 53–62.)

The order includes over 70 genera and 1,000 species of very diverse habit, and is only slightly represented in New Zealand by 4 genera and 12 species. *Rubus australis* (Lawyer or Bramble) is probably common in Australia. *Potentilla anserina* (Silver Weed) is an ubiquitous species. *Geum* (3 sp.) is a widespread genus, of which only one doubtful species is endemic. *Acæna* (Piri-piri) is represented by 7 species, of which 2 are of wide distribution in the Southern Hemisphere, while the others are endemic.

In an economic sense the order is chiefly remarkable for the number of edible-fruited species belonging to it. These include Peach and Nectarine (*Persica*), Almond (*Amygdalus*), Apricot (*Armeniaca*), Plum and Cherry (*Prunus*), Apple and Pear (*Pyrus*), Quince (*Cydonia*), Medlar (*Mespilus*), Loquat (*Eriobotrya*), Rasp- and Black-berry (*Rubus*), and Strawberry (*Fragaria*). The seeds and sometimes also the leaves (*e.g.*, Cherry Laurel) of many of the species contain Hydrocyanic (Prussic) Acid, which gives the characteristic smell and flavour of bitter almonds.

Many species in addition to the above are cultivated—*e.g.*, Roses, *Cratægus* (Hawthorn), *Pyrus* (Mountain-ash, &c.), *Spiræa*, *Cotoneaster*, &c.

Order XXVIII. Myrtaceæ.

Trees or shrubs. Leaves opposite, rarely alternate, exstipulate, simple, entire, more or less dotted with resinous glands, which are usually pellucid. Flowers regular, solitary

and axillary, or in racemes, panicles, or cymes. Calyx-tube adnate to the ovary; limb usually 4- or 5-cleft. Petals as many as calyx-lobes, imbricate in bud, sometimes joined together into an operculum, which falls off as the flower opens. Stamens ∞, usually very numerous, filaments free or more or less coherent at the base, anthers small, 2-celled. Ovary inferior, 2- or more usually 4–5-celled, rarely 1-celled; style simple, stigma undivided; ovules usually numerous and anatropous. Fruit dry and indehiscent, or capsular and opening loculicidally by as many valves as cells, or an indehiscent berry. Seeds exalbuminous, embryo straight or curved. (Pp. 45–47, figs. 63–66.)

A very large order, especially in the tropics and in the south temperate zones. The genera with fleshy fruits are widely spread over the tropics, while those with capsules are chiefly Australian. The order is represented in New Zealand by some 17 species, belonging to 4 genera. Of the two species of *Leptospermum*, or Manuka, one of them, *L. scoparium*, is also found in Australia; the other, *L. ericoides*, is peculiar to these islands. *Metrosideros* (10 sp., including Ratas, Ironwood, Pohutukawa, &c.) is a genus found also in the South Sea Islands, but not in Australia. *Myrtus*, represented by 4 endemic species of Myrtles, is found over Europe, Western Asia, South America, and Australia. *Eugenia*, 1 sp., is a genus widely spread in the tropics.

The order contains a number of useful plants. Perhaps its most important genus is *Eucalyptus*, which includes the gum-trees of Australia (Blue Gum, Peppermint, Red Gum, Stringy Bark, &c.). These yield valuable timber, while some of the species are among the largest trees known, not unfrequently attaining a height of 250ft. Cloves are the dried leaves of *Caryophyllus aromaticus*. Several genera yield edible fruits, of which the best known is the Guava (*Psidium*). Brazil-nuts are the seeds of a species of *Bertholletia*. The European Myrtle (*M. communis*) is one of the few species cultivated in gardens for its beauty.

Order XXX. Onagrarieæ.

Herbs, shrubs, or small trees; leaves simple, exstipulate. Flowers regular. Calyx-tube adnate to the ovary, often produced beyond it into a (2–)4-lobed valvate limb. Petals (2 or) 4, contorted, or very small, rarely 0, inserted on the edge of the calyx-tube. Stamens (as many or) twice as many as the petals, inserted with them. Ovary (2–)4-celled, with a straight style and entire or 4-lobed stigma; ovules ∞ in each cell. Fruit a capsule or berry; seeds small exalbuminous, sometimes furnished with a tuft of hairs. (Pp. 47–49, figs. 67–72.)

A somewhat small but well-defined order, including 22 genera and 300 species, chiefly found in temperate regions. Only 2 genera occur in this colony. Of these, *Fuchsia* is represented by 3 (or 4) endemic species; all the other species of the genus occurring in the Andes of South America. *Epilobium*, a widespread genus, is well represented by about 17 sp., many of which, however, are of doubtful specific value.

There are no important plants belonging to the order; but several are cultivated for their flowers—*e.g.*, *Godetia*, *Clarkia*, and *Œnothera* (Evening Primrose). Some of these have gone wild in parts of the colony.

Order XXXIV. Umbelliferæ.

Herbs, rarely shrubby, usually aromatic or rank-smelling when bruised. Stems often hollow, solid at the nodes. Leaves alternate, usually much divided, rarely simple; petiole with a membranous sheath at the base. Flowers small, arranged in simple or usually compound umbels, sometimes in heads with or without involucral bracts. Calyx-tube adnate with the ovary; limb 5-toothed or wanting. Petals 5, epigynous; tips usually incurved. Stamens 5, alternate and inserted with the petals; filaments bent inwards in bud. Ovary 2-celled (rarely 1-celled by abortion); styles 2, often broadened at their base into stylopodia, which crown the ovary; ovule 1 in each cell, pendulous. Fruit separating into 2 dry indehiscent carpels, which sometimes remain suspended from a central axis or *carpophore;* each carpel longitudinally 5–9-ribbed, and the pericarp usually traversed by oil-canals, or vittæ. Seed usually adherent to the pericarp; embryo minute, in horny endosperm. (Pp. 50–52, figs. 73–82.)

A large order, most abundant in the north temperate zone, including over 150 genera and 1,300 species, and represented in these islands by 11 genera and about 50 species. Of these, *Hydrocotyle* (10 sp.) is a widespread genus; only 1 or 2 of the local species are endemic. *Azorella*, an antarctic genus, is represented by 7 species, all endemic. *Crantzia lineata*, both our species of *Apium*, and *Eryngium vesiculosum* are widely spread in the Southern Hemisphere. Of *Actinotus*, an Australian genus in which the ovary is only 1-celled, one species occurs in Stewart Island. *Oreomyrrhis*, another southern genus, is represented by 3 endemic species. *Aciphylla* (Spear-grass), the most characteristic of our Umbelliferæ, has 6 endemic species; one or two species also occur in the mountains of south-eastern Australia. *Ligusticum* (14 sp.) and *Angelica* (4 sp.) are widespread genera, but all the local species are endemic. *Daucus brachiatus*, a native Carrot, is common in the Southern Hemisphere. A few introduced species have become wild in this colony.

A large number of useful plants belong to the order. Celery (*Apium*), Parsley (*Carum*), Parsnip (*Pastinaca*), and Carrot (*Daucus*) are common culinary plants. Caraway, Anise, Fennel, Coriander, Samphire, Lovage, Angelica, Cumin, &c., are aromatic herbs. Many are poisonous—*e.g.*, Hemlock, Water Hemlock, Fool's Parsley, &c. Certain resinous substances used in medicine are obtained from plants of the order—*e.g.*, Gum Assafœtida.

Order XXXVIII. Rubiaceæ.

Shrubs or trees (rarely herbs) with opposite stipulate leaves, or herbs in which the stipules so resemble the leaves as to make the latter appear whorled; leaves simple, entire. Calyx-tube adnate to the ovary; limb 2–5-lobed or 0. Corolla epigynous, rotate, campanulate or tubular, 4–8-lobed, usually valvate. Stamens as many as corolla-lobes, epipetalous. Ovary 2- (rarely 3-) celled, with 2 styles; ovule 1 in each cell. Fruit a drupe, or dry and indehiscent; seeds with small embryo having flat cotyledons, in horny endosperm. (Pp. 61–63, figs. 108–112.)

A large and varied order, of 337 genera and about 4,100 species, of which the majority are tropical. Only 4 genera, with about 34 species, are found in New Zealand. Of these, the genus *Coprosma*, with some 27 species, reaches its maximum development in these islands, a few other species ranging to Australia, Borneo, and the Pacific Islands. All our species are endemic. *Nertera* (4 sp.) has 2 endemic species and 2 of wider distribution. *Galium* (2 sp.) and *Asperula* (1 sp.) are commonly-distributed genera, but all our species are endemic. *Galium aparine* and *Sherardia arvensis*, common European plants, have become naturalised here.

The order contains a number of valuable plants. Quinine, Cinchonine, and some other vegeto-alkaloids are obtained from the bark (Peruvian bark) of various species of *Cinchona*. Ipecacuanha is the root of a Brazilian plant (*Cephaëlis*). Coffee is the seed of a species of *Coffea*, indigenous to Abyssinia. Madder, which dyes Turkey-red, is the root of *Rubia tinctorium;* its cultivation has nearly ceased, as its colouring principle, *Alizarine*, is now prepared cheaply from coal-tar products. *Bouvardia* is almost the only genus cultivated for its flowers.

Order XXXIX. Compositæ.

Herbs, shrubs, or trees; leaves usually alternate, simple or compound, exstipulate. Flowers (florets) minute, sessile, crowded into capitula which are surrounded by 1 or more series of involucral bracts. Capitula solitary on scapes, or arranged in cymes, corymbs, or panicles. Bracts sometimes coloured and simulating petals. Floral receptacle flat or conical, naked or covered with chaffy scales or paleæ. Florets usually of two kinds: all, or inner only, tubular, ♂ or ☿; or outer ♀ or ☿, often ligulate. Calyx-tube adnate to the ovary; limb 0, or of scales or hairs (pappus). Corolla either tubular or campanulate, 4–5-lobed and valvate; or ligulate. Stamens 5, epipetalous; anthers syngenesious, often produced downwards into tails. Ovary 1-celled, inferior, with 1 erect ovule; style 2-fid. Achene enclosed in the adnate calyx-tube. Seed exalbuminous, with plano-convex cotyledons and short radicle. (Pp. 57–61, figs. 99–106.)

The largest of all natural orders, with nearly 800 genera and 10,000 species, distributed over all parts of the globe. It is also the largest order in New Zealand, having 24 genera and nearly 170 species. The affinities of most of the genera are Australian; only the more remarkable and characteristic are noted here.

Olearia has 26 species, all endemic—the genus is chiefly Australian; *Pleurophyllum*, a remarkable genus of 2 species, allied to *Olearia*, and confined to the islands lying south of New Zealand; *Celmisia*, a fine genus of some 28 species, of which only one ranges outside of New Zealand, and occurs on the mountains of Tasmania and south-east Australia; *Abrotanella*, 5 species, all endemic, a genus of greatly-retrograded Antarctic composites; *Cotula*, a widespread genus, 7 out of the 13 species found here are endemic. Of the great and widely-distributed genus *Helichrysum*, all of our 14 species are endemic. *Raoulia*, an allied genus, is characteristic of these islands; its 14 representative species are all endemic, and only 1 (or 2) occurs in Australia. *Haastia*, a peculiar and endemic genus of 3 or 4 species. Of *Senecio*, one of the largest genera of flowering plants, 24 out of our 26 species are endemic, the other 2 being Australian also. *Brachyglottis* is an allied genus of 1 endemic

species. Five genera belong to the division Liguliflorae—viz., *Microseris*, *Crepis*, *Taraxacum* (Dandelion), *Picris*, and *Sonchus* (Sow-thistle)—each represented by a single species. Of these, *Crepis novæ-zealandiæ* is endemic, the others being widely spread, a fact due probably to their well-developed pappus. Numerous species of introduced Composites have become naturalised in the colony.

The plants of such an immense order naturally include many that are of great value. Among food-plants we find Artichoke (*Cynara*), Chicory (*Cichorium*), Lettuce (*Lactuca*), Salsafy (*Tragopogon*), Scorzonera, Jerusalem Artichoke (*Cynara*), &c. Medicinal or aromatic substances are yielded by Wormwood (*Artemisia*), Chamomile (*Matricaria*), Tansy (*Tanacetum*), Colt's-foot (*Tussilago*), *Arnica montana*, and others. The seeds of Sunflower (*Helianthus*) and species of *Madia* yield valuable oils, while the flowers of Safflower (*Carthamus tinctorius*) yield a beautiful red dye called Carthamine. Numerous genera are cultivated for their flowers.

Order XLIV. Ericaceæ.

Shrubs or trees; leaves alternate or opposite, simple, exstipulate, usually coriaceous. Flowers regular, bracteate. Calyx inferior, 5-fid or nearly free. Corolla tubular or campanulate, 5-lobed or -toothed, throat often hairy, lobes imbricate in bud. Stamens 5 or 10, hypogynous or epipetalous; anthers 1- or 2-celled, opening by terminal pores or slits, often furnished with awns. Disc 5–10-lobed, or of 5 scales. Ovary 1–10-celled, with simple style, usually capitate or lobed stigma, and 1 or more ovules in each cell. Fruit a capsule, berry, or drupe, free or enclosed in the calyx-tube, which sometimes becomes succulent. Seeds small; testa reticulate; embryo minute in fleshy endosperm. (Pp. 63–65, figs. 113–115.)

Sub-order I. Ericeæ.

Stamens hypogynous; anthers 2-celled, opening by terminal pores.

This is usually treated as a distinct order from Epacrideæ, but the staminal characters are really the only structural point of distinction between the two. It includes 52 genera and about 1,000 species, widely distributed. New Zealand possesses only 2 genera—viz., *Gaultheria* (to which the Snowberry belongs), 4 species, 3 of which are endemic, while *G. antipoda* also occurs in Tasmania; and *Pernettya*, 1 sp., also found in Tasmania, though the other species of the genus are all South American.

The sub-order does not contain many useful plants. The flowers of some genera yield very poisonous honey. Many are cultivated for their beautiful flowers or fruit—*e.g.*, *Erica* (Heath), *Arbutus* (Strawberry-tree), *Kalmia*, and *Rhododendron* (some species of which are separated by gardeners as a distinct genus *Azalea*).

Sub-order II. Epacrideæ.

Stamens epipetalous (or hypogynous); anthers 1-celled, opening by slits.

This sub-order consists chiefly of Australian Heaths, and includes 26 genera and about 320 species. Of these, 6 genera occur in New Zealand, represented by 28 species. These are *Cyathodes*, 5 sp. (all endemic), *Leucopogon*, 3 sp. (2 endemic), *Pentachondra*, 1 sp. (also found in Australia), *Epacris*, 4 sp. (2 or 3 endemic), *Archeria*, 2 sp. (endemic), and *Dracophyllum*, 13 sp. (all endemic). It will be seen that, while the genera are chiefly Australian or Tasmanian, the majority of the New Zealand forms are peculiar to these islands.

None of the order are of importance, but a few species are cultivated for their flowers.

Order LII. Boragineæ.

Herbs, usually hispid (rarely glabrous); leaves alternate, quite entire, exstipulate, often strongly nerved. Flowers usually produced in scorpioid cymes. Calyx 5-lobed or -partite, valvate in bud. Corolla regular, frequently rotate, 5-lobed, lobes imbricate in bud, throat often closed with scales. Stamens 5, epipetalous, filaments usually short, anthers 2-celled. Carpels 2, each 2-lobed to the base and 2-celled; ovule 1, pendulous in each cell; style gynobasic. Fruit of 4 indehiscent 1-seeded nucules; seed with straight embryo, foliaceous cotyledons, superior radicle, and little or no endosperm. (Pp. 67–68, figs. 121–123.)

The order is a large one, and of wide distribution. It includes 68 genera and about 1,200 species, of which 2 genera, represented by 15 or 16 species, occur in New Zealand. Of these, *Myosotis* (Forget-me-nots), with 14 species, is a widely-spread genus; but 12 of our species are endemic, 1 ranges into South America, and 1 into Australia. *Myosotidium* is a singular genus, represented by only 1 species—*M. nobile* (Chatham Island Lily), which is only found in the Chatham Islands. It is allied to the widely-spread genus *Cynoglossum*, or Hound's-tongue, which, however, does not occur in this colony.

There are very few plants of any economic importance in the order. Some genera (besides those named above) are cultivated for the sake of their flowers—*e.g.*, *Heliotropium*, *Borago* (Borage), *Cerinthe*, &c.

Order LVI. Scrophularineæ.

Herbs or shrubs, rarely trees; leaves opposite or alternate, exstipulate. Flowers usually irregular; pedicels with 1 or 2 axillary bracteoles. Calyx 3–5-partite, inferior, usually persistent. Corolla 4–5-lobed, often 2-lipped; lobes imbricate in bud. Stamens 2, or 4 and didynamous, sometimes with a rudimentary fifth; anthers 1- or 2-celled. Ovary 2-celled; style simple; stigma capitate or 2-lobed; ovules numerous in each cell. Fruit a capsule, dehiscing variously; seeds small, with straight embryo in fleshy endosperm. (Pp. 69–72, figs. 126–133.)

A large and natural order of wide distribution, including nearly 160 genera and 1,900 species. In this country there are 9 genera, with about 70 species, this latter number varying with the number of species of *Veronica* which are accepted. *Calceolaria* has two species, both endemic; the genus is mainly South American. *Mimulus*, 2 sp., of which *M. repens* ranges into Australia. *Mazus pumilio* and *Gratiola*, 2 sp., have the same distribution. *Glossostigma elatinoides* is endemic, while *Limosella aquatica* is found in all temperate regions. *Veronica* is one of the most characteristic genera of New Zealand, as in no other part of the world does it reach such remarkable development as it does here, the majority of the local species being shrubs, often of large size. With the exception of *V. elliptica*, which also occurs in the southern part of South America, and *V. anagallis*, which is widely distributed, all the rest are endemic species. Their number is variously estimated between 40 and 60, or even more, by different botanists; but the various species tend to pass more or less into one another. The extreme forms differ most remarkably from each other in habit and appearance. *Ourisia*, an Antarctic genus, is represented by

6 endemic species; while *Euphrasia* has also 6 sp., of which 2 are endemic, 2 resemble Australian, and 2 Chilian forms.

Some introduced species of *Verbascum* (Mullein), *Mimulus* (Musk, &c.), *Veronica* (Speedwell), and *Bartsia* have run wild.

With the exception of Foxglove (*Digitalis purpurea*), which yields a powerful medicinal principle—*digitaline*—few plants of the order are of any value. But it abounds in beautiful and much-cultivated flowers—*e.g.*, in addition to those already named are *Alonsoa*, *Linaria* (Toad-flax), *Antirrhinum* (Frog's-mouth or Snapdragon), *Maurandia*, *Pentstemon*, *Collinsia*, and *Torenia*.

Order LXIII. Polygoneæ.

Herbs or shrubs; leaves alternate, entire, revolute when young; stipules ochreate. Flowers regular. Perianth 5–6-partite or free, in 1 or 2 series, persistent, enclosing the fruit. Stamens 6–8, perigynous, opposite the perianth-lobes. Ovary free, 1-celled, 3-gonous or compressed; styles 1–3, stigmas capitate, often feathery; ovule 1, erect. Fruit an achene, enclosed in the dry or succulent perianth-tube. Seed with straight and axile, or curved and lateral embryo in mealy endosperm. (Pp. 80–82, figs. 151–155.)

An order of wide distribution in temperate regions, including 33 genera and about 500 species. The following occur in New Zealand: *Polygonum*, 2 sp., both widespread; *Muhlenbeckia*, 4 sp., all apparently with distribution outside of New Zealand; and *Rumex* (Dock), 2 sp., of which *R. flexuosus* occurs in Australia also. Several species of *Rumex* have become naturalised—*e.g.*, the common Docks *R. obtusifolius* and *R. crispus*, the Sorrels *R. acetosa* and *R. acetosella*, and Black Bindweed (*Polygonum convolvulus*), &c.

The order contains a few useful plants, as Rhubarb (*Rheum*) and Buckwheat (*Fagopyrum*).

MONOCOTYLEDONS.

Order I. Orchideæ.

Perennial herbs, either terrestial with tuberous or fascicled roots, or epiphytes with aerial roots and often thickened fleshy branches (*pseudo-bulbs*). Leaves usually sheathing at the base or reduced to scales, entire. Flowers ☿, solitary, spiked, racemed or panicled, bracteate. Perianth superior, usually petaloid, irregular, of 6 leaves in two series; 3 outer (sepals) usually equal, 2 of them lateral and 1 inferior (often superior by the twisting of the ovary); 3 inner (petals) having the 2 lateral similar, and the third (*labellum*) usually larger and different in shape and often in colouring. Stamens united with the style into a column facing the labellum: as a rule, only 1 stamen is developed, its 2-celled anther terminating the column, and containing 2, 4, or 8 masses of pollen (*pollinia*), which are usually fastened together in pairs by a caudicle to a gland placed near the projecting tip (*rostellum*) of the column; sometimes 2 imperfect stamens, or staminodia, are developed on the sides of the column (these are nor-

mally produced in *Cypripedium*, while the terminal anther is modified to serve as a shield). Ovary inferior, 1-celled, with numerous minute ovules on 3 parietal placentæ; style forming the front of the column and terminating in the rostellum; stigma consisting of a viscid surface, usually 2-lobed, and often concave, on the face of the column. Fruit a capsule, generally dehiscing by 3 valves, which separate from the midribs of the carpels. Seeds very numerous, minute, with very loose reticulate testa, no endosperm, and a fleshy embryo. (Pp. 93–98, figs. 180–196.)

This is one of the largest orders of flowering plants, consisting of some 350 genera and nearly 5,000 species, distributed over all parts of the earth except the very coldest. The epiphytal forms are most abundant in tropical regions. It is also one of the, if not *the*, most remarkably developed of all orders of flowering plants, the diversity of form of the flowers and the extreme specialisation of many of them being extraordinary. In New Zealand there are 18 genera, represented by 41 species, the general affinity of all of them being either Australian, Polynesian, or Malaysian; but two genera—*Earina* (2 sp.) and *Adenochilus* (1 sp.)—are endemic. The following are the other genera: *Dendrobium* (*cunninghamii*), perhaps the same as a Polynesian species; *Bolbophyllum* (*pygmæum*) and *Sarcochilus* (*adversus*), both endemic;—these three, with *Earina*, are our epiphytal species: *Gastrodia* (*cunninghamii*), endemic, a curious erect leafless plant; *Acianthus* (1 sp.), *Cyrtostylis* (2 sp.), and *Corysanthes* (6 sp.) are all endemic; the latter are pretty little plants found growing in shady places, each with 1 leaf and 1 purple flower; *Microtis* (1 sp.), *Caladenia* (2 sp.), *Chiloglottis* (2 sp.), and *Lyperanthus* (1 sp.) are also endemic; *Pterostylis* (8 sp., of which 3 are endemic, and the rest either Australian or closely allied to Australian species); similarly *Thelymitra* (6 sp.) has 2 endemic, and the rest Australian species; *Prasophyllum*, 3 sp. also found in Tasmania or Australia; *Spiranthes*, 1 ubiquitous species; and *Orthoceras*, 1 sp., closely allied to an Australian form. With a few exceptions, the local forms are not remarkable for striking peculiarities in their mode of fertilisation, as is the case with so many other forms.

The order yields very few useful products, the most important being the capsules of *Vanilla*, which emit a very delicious perfume. The flavouring principle (vanillin) is now prepared to a considerable extent from coal-tar products.

Orchids are chiefly cultivated for the beauty and magnificence of their flowers. Their cultivation is a special branch of horticulture, and the passion for orchid-growing has of late years become a perfect mania in parts of Europe.

Order IV. Liliaceæ.

Herbs, rarely shrubs or trees, of very various habit, with bulbs, or fibrous roots, or creeping rhizomes. Flowers regular, ☿ or rarely unisexual. Perianth inferior, of 6 coloured leaflets in 2 series, or 6-lobed. Stamens 6, hypogynous, or inserted on the perianth; anthers oblong or linear. Ovary 3-celled, or rarely 1-celled, with 3 parietal placentæ; style usually simple, stigmas 3-lobed; ovules 2 or more, rarely 1, in each cell. Fruit a 3-celled loculicidal capsule or a 1–3-celled berry; seeds rounded or flattened, with small terete embryo and horny or fleshy endosperm. (Pp. 91–93, figs. 174–179.)

A very large order of wide distribution, including nearly 190 genera and 2,100 species. In New Zealand we have 10 genera and 23 species, belonging, however, to several different tribes. *Rhipogonum scandens* (Supple-jack) and *Luzuriaga* (*Callixene*) *parviflora* have netted-veined leaves; both are endemic, but the former is allied to Australian and the latter to South American species. *Cordyline* (Cabbage-tree), with 5 species, all endemic, is of Australian and Polynesian affinity. 7 species of *Astelia* occur, all endemic and diœcious, but the genus ranges from Australia to South America. *Dianella* (1 sp.), *Arthropodium* (2 sp.), *Herpolirion* (1 sp.), and *Iphigenia* (1 sp.) are of Australian affinity. *Anthericum* (2 sp., both endemic), is a genus of wide distribution: *A. rossii* is only found in the Auckland and Campbell Islands; *A. hookeri* in New Zealand proper. The most characteristic genus is *Phormium* (New Zealand Flax), consisting of 2 species, both of which are endemic, ranging, however, as far as Norfolk Island.

The order contains many useful plants. Well-known medicinal products are yielded by the leaves of various species of *Aloe*, the bulbs of *Scilla maritima*, and the roots of certain species of *Smilax* (Sarsaparilla). Other useful plants are the various forms of *Allium* (including Garlic, Onion, Leek, Shallot, &c.), and *Asparagus*. A large number of genera are cultivated for their flowers—*e.g.*, *Lapageria*, *Polygonatum* (Solomon's Seal), *Convallaria* (Lily of the Valley), *Hemerocallis* (Day Lily), *Funkia*, *Yucca* (Adam's Needle), *Agapanthus*, *Scilla* (Squills), *Muscari* (Grape Hyacinth), *Hyacinthus*, *Chionodoxa*, *Ornithogalum* (Star of Bethlehem), *Lilium*, *Fritillaria*, *Tulipa*, *Colchicum* (Autumn Crocus), &c.—all names familiar to gardeners.

Order XII. Cyperaceæ.

Grass-like or rush-like herbs, usually perennial. Stems solid, mostly 3-gonous. Leaf-sheaths closed (not split as in grasses), blades often with scabrid margins. Flowers ☿ or unisexual, in spikelets consisting of several small scale-like bracts (*glumes*) imbricated round the rachis or distichous, with *one* sessile flower in the axil of each, or the lower ones and sometimes a few at the end empty. Spikelets usually collected into simple or compound spikes, panicles, or irregular umbels. Glumes concave, usually rigid, sometimes awned. Perianth 0, or formed of 3–6 or more hypogynous bristles or scales. Stamens 1–6, usually 3, hypogynous; filaments free, more or less flattened; anthers basifixed, 2-celled, connective often produced into a small terminal appendage. Ovary 1-celled, with 1 erect anatropous ovule (enclosed in *Carex* and *Uncinia* in a coriaceous utricle); style 1, divided above into 2 or 3 filiform stigmatic branches. Fruit a small flattened or 3-angled nut. Seed erect, with floury endosperm, at the base of which is a small lenticular or ovoid embryo. (Pp. 99–101, figs. 197–203.)

A large and widely-distributed order of plants, which are especially to be found in moist situations. About 100 genera and 2,000 species are known, the largest number occurring in the colder regions of the Northern Hemisphere. In New Zealand 14 genera occur, represented by nearly 100 species, of which over 40 belong to the genus *Carex*. The only endemic genus is *Desmoschœnus*, represented by one species, *D. spiralis*, which is a common plant on our sea-shores. *Carpha*, *Gahnia*, *Lepido-*

sperma, *Uncinia*, and *Oreobolus* are genera almost or quite confined to the Southern Hemisphere; the other genera are world-wide in their distribution. The so-called "cutting-grasses" are mostly members of this order. The plants of the genus *Uncinia* are remarkable from the occurrence in the female flowers of a long rigid hooked bristle, which arises within the utricle from its base, and which serves as a very perfect means of distributing the seeds.

None of the plants of the order are of any considerable economic importance.

Order XIII. Gramineæ.

Herbs, usually tufted, with cylindrical or compressed stem, which is jointed, and usually hollow between the joints. Leaves alternate, distichous, narrow, sheath split to the base, usually furnished with a ligule. Inflorescence of spikelets arranged in spikes, racemes, or panicles; each spikelet consisting of a pair of bracts (empty glumes) enclosing one or more flowering-glumes, which, however, are also sometimes empty. Flowers usually ☿, more rarely unisexual. Flowering-glume unequally nerved or keeled, often furnished with an awn; inner glume, or palea, flat and 2-nerved, enclosed by the flowering-glume. Perianth reduced to 2 (rarely 0 or 3) minute, often oblique scales (lodicules). Stamens 3 (rarely 1, 2, 4, 6, or more), with capillary filaments and 2-celled versatile pendulous anthers. Ovary 1-celled, with 1 erect ovule; styles 2, with feathery or hairy stigmas. Fruit a caryopsis, the seed adhering closely to the pericarp, and sometimes to the palea. Seed with floury albumen; embryo outside the base of the endosperm. (Pp. 101–103, figs. 204–207.)

Grasses form one of the most natural of the orders of flowering plants. Their number (as is the case in all difficult orders) is variously estimated, but Bentham ("Genera Plantarum") considers there are about 300 genera and 3,200 species. They are distributed over all parts of the globe. In New Zealand we have 30 genera and about 80 species. Many of these are endemic, but others are common in Australia or South America, while others, again, are very widespread. *Arundo conspicua* (Toi-toi grass) is endemic, and is the largest species in these islands. Other striking endemic species are *Danthonia cunninghamii*, *D. raoulii*, and *D. flavescens* (the latter often called Snow-grass), *Poa foliosa*, *P. colensoi*, and *P. lindsayi*, and *Gymnostichum gracile*, the latter closely allied to a North American species.

The order contains an immense number of useful plants. The genera *Poa* (Meadow-grasses), *Lolium* (Rye-grass), *Alopecurus* (Foxtail), *Phleum* (Timothy or Cat's-tail), *Dactylis* (Cocksfoot), and *Festuca* (Fescue) furnish the most important of the pasture-grasses. The relative values of the various New Zealand species for pasturage purposes have not been fully investigated yet. The cereal grasses include Wheat (*Triticum*), Rye (*Secale*), Barley (*Hordeum*), Oats (*Avena*), Rice (*Oryza*), Millet (*Panicum*), Maize (*Zea*), *Sorghum*, &c. Several species yield sugar, in particular the Sugar-cane (*Saccharum*). The Bamboo (*Bambusa* of many species) serves for an infinity of purposes to the inhabitants of southern and south-eastern Asia.

GLOSSARIAL INDEX.

∞ = indefinite.
♂ = male, or staminate.
♀ = female, or pistillate.
☿ = hermaphrodite.

INDEX OF PLANT NAMES AND PRODUCTS.

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